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FLOOD PLAIN MANAGEMENT IN THE DRUMHELLER VALLEY: ALTERNATIVE LAND USE POLICIES

by

© MARGARET JANE STAITE

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES IN

PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF ARTS

DEPARTMENT OF GEOGRAPHY

EDMONTON, ALBERTA

FALL, 1979

THE UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled FLOOD PLAIN MANAGEMENT IN THE DRUMHELLER VALLEY: ALTERNATIVE LAND USE POLICIES submitted by MARGARET JANE STAITE in partial fulfilment of the requirements for the degree of MASTER OF ARTS.

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Date . Oct. 3. 1979

ABSTRACT

In this thesis study, alternative land use management policies and associated adjustments that may be employed to reduce the Drumheller Valley flood hazard and potential damage in the flood plain have been investigated. The discussion of alternative policies has been focussed primarily upon land use adjustments; nevertheless, alternative adjustments were discussed and recommendations for future management and research in these areas have been made.

The Drumheller Valley area discussed in the thesis is within two Alberta municipalities, the City of Drumheller and Improvement District Number Seven (I.D. No. 7). It is located along the Red Deer River, 180 kilometers downstream from Red Deer and 120 kilometers north-east of Calgary. In 1978, approximately one-third of the 7,017 Drumheller Valley residents lived on the 1:100 year flood plain. Eighty-three percent of the 783 flood plain buildings were single family dwellings. Sixty-eight percent of the flood plain development was in the four City of Drumheller communities; 29% was in the I.D. No. 7 hamlets and 3% was in rural I.D. No. 7.

In 1978, the Alberta Department of the Environment, Planning Division initiated the Drumheller Flood Control Study, in which alternative means of reducing Drumheller Valley flood damages are being identified and evaluated. The research for this thesis was funded by the Planning Division; parts of the thesis have been rewritten in two parallel reports that make up the "land uses and regulations" component of the Drumheller Flood Control Study.

The alternative land use policies suggested in the thesis were based on a systematic investigation of several information sources. First,

general flood plain management and flood hazard reduction literature was reviewed. Second, the history of Drumheller Valley flood was discussed; adjustments used in the past and those available at present were examined. Third, legislation and bylaws affecting flood plain land use management in the Drumheller Valley were reviewed.

Within this theoretical and legal framework, the existing Drumheller flood plain land use policy was outlined and alternative policies were suggested for five categories of developed and undeveloped land: vacant undeveloped land, new subdivision applications, vacant subdivided lots, developed subdivided lots and abandoned buildings. Potential social, economic and environmental effects of the alternative land use policies were discussed. The land use patterns of the ten Drumheller Valley communities were surveyed, described and mapped. Then, the effects of the alternative land use policies were suggested for developed and undeveloped land in each community, and policies for the future flood plain management of each community were recommended.

It was found that existing Alberta legislation allows for more consistent and specific flood plain management and development policies than those being used in the Drumheller Valley municipalities. However, provincial guidance may be needed by the municipal governments in areas such as the provision of a legal definition of the flood plain and the provision of provincial policy statements about the goals of flood plain management in Alberta. It was suggested that there is a need to coordinate provincial and municipal policies and programs dealing with flood plain management and flood loss compensation. These include the Alberta Department of the Environment flood forecasting and flood protection programs, the Alberta Disaster Services emergency action

and public relief progams, regional planning commission subdivision approval policies and municipal government development control policies.

Because the degree and nature of flood plain development in the City of Drumheller and I.D. No. 7 were not the same, it was suggested that different flood plain management policies be adopted by the two Drumheller Valley municipalities. Protective works should be combined with flood proofing to protect the intensively developed City of Drumheller communities against minor to moderately severe flooding (for example 1:25 year floods). In I.D. No. 7, where rural and hamlet development appears to be largely outside of the 1:25 year flood plain, a two-zone flood plain management policy should be initiated, whereby further residential and commercial development of the 1:25 year flood plain is not allowed and new development of the floodway fringe will be allowed with flood proofing. In the entire Drumheller Valley, it was recommended that future subdivision of the 1:25 year flood plain not be allowed and that new subdivision and development not be allowed behind protective works.

It was concluded that management of flood plain land uses, in itself, is not sufficient to eliminate flood damages in the Drumheller Valley. However, in conjunction with other adjustments, such as emergency measures, protective works and public education, a clear flood plain management policy could be developed for control of new subdivision of unprotected areas and for prevention of intensive development in protected areas that could be damaged by a flood exceeding design capacity. In Alberta, there is a need for additional flood hazard research, reassessment of existing flood plain management policies and greater coordination of provincial and municipal programs to reduce flood losses.

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The study was supported by a contract with the Planning Division of the Alberta Department of the Environment. Mr. C. Primus, Mr. D. Hart and Mr. R. Hardie of the Planning Division should be thanked for allowing me to contribute to the Drumheller Flood Control Study, especially Mr. Hart and Mr. Hardie for their helpful comments and review of material. The planning staff of the Calgary Regional Planning Commission and the Red Deer Regional Planning Commission aided in the conceptualization of the land use portion of the study. Mr. P. Fenwick and the planning staff of the Palliser Regional Planning Commission commented on the interpretation of Alberta legislation and the municipal bylaws affecting flood plain development in the Drumheller Valley.

Special thanks go to Mr. D. Guidolin and the staff at Drumheller City Hall, to the I.D. No. 7 administrative staff in Edmonton and to

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CHAPTER I

INTRODUCTION

1.1 The Problem

In 1978, almost one-third of the seven thousand Drumheller Valley residents lived on the 1:100 year flood plain. In 1976, it was estimated that 1:100 year flood damages in the Drumheller Valley could reach almost six million dollars. Nevertheless, there is not a coordinated provincial-municipal program to manage flood-prone land in the valley.

There have been at least fourteen floods in the Drumheller Valley since it was first settled in 1896. However, the Red Deer River has not flooded in this area since 1954. The only flood in the Drumheller Valley during the past 25 years was a minor overbank flow of the Rosebud River in 1965. Badland topography and undermining from abandoned coal mines restrict settlement to the valley floor, a large proportion of which is flood plain.

The Alberta government has introduced flood forecasting, emergency preparedness and relief programs to reduce flood damage costs incurred by the province, municipalities and private citizens in flood-prone areas of Alberta, including the Drumheller Valley (Alberta, Department of Environment 1977, p.45; Hennie 1977, p.91). Furthermore, the Alberta Department of the Environment, Planning Division has undertaken the Drumheller Flood Control Study to evaluate alternative means of reducing the Drumheller Valley flood damage potential (1979, p.1). Both the Canadian and American governments have recognized that although flood control mea-

sures and compensation are frequently necessary, they are not sufficient to prevent flood damages (Canada, Department of Fisheries and Environment 1978b, p.93; U.S. Water Resources Council 1976, p.II 1-6). If the existing Alberta programs are to mitigate Drumheller Valley flood damages, future flood plain development in the Drumheller Valley must be managed in a manner compatible with the flood hazard.

The new Alberta Planning Act (1977) provides the legal framework for municipal governments and regional planning commissions to manage flood plain development through subdivision approval and municipal development control bylaws. However, the two Drumheller Valley municipalities, the City of Drumheller and Improvement District Number Seven (I.D. No. 7) and their planning advisor, the Palliser Regional Planning Commission (PRPC) have not yet utilized these mechanisms to their full potential. Indeed, the need for a flood plain management policy for the Drumheller Valley was documented by the Calgary Regional Planning Commission (CRPC) in the Drumheller Valley General Plan (1977a). The first recommendation (p.ix) was that the "City of Drumheller and I.D. No. 7 Administration and Alberta Environment should establish a joint policy for development in the Red Deer River flood plain".

1.2 Setting

The 28-kilometer (km) long Drumheller Valley is located along the Red Deer River, 180 km downstream from Red Deer and 120 km east of Calgary.

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[1] In 1978, the regional planning commission boundaries were changed and the newly formed PRPC replaced the CRPC as the planning advisor in the Drumheller Valley.

The broad valley floor is approximately 100 meters (m) below the rolling prairie; the valley sides are badland topography composed of eroding sandstones and shales, with their included bentonite, coal and fossil deposits.

The ten communities examined in the study are located on the Red Deer River flats, largely on slip-off slopes at the inside of meander bends (Figure 1.1). These include parts of five hamlets in I.D. No. 7: Nacmine, Rosedale, Cambria, Lehigh and East Coulee. The squatter[2] community on the Aerial flats is included with Rosedale; the one dwelling remaining in Eladesor is included with Cambria; the squatters in Western Monarch are included with East Coulee. In this study, the City of Drumheller was divided into four communities: Midlandvale, Newcastle, North Drumheller and Drumheller. Each was formerly a separate municipality. Rural areas within I.D. No. 7 were the tenth community.

The 1976 Drumheller Valley population was 7,017 (CRPC 1978, p.1-3). The first settlers were ranchers who arrived in 1896. The real settlement impetus came in 1911, when the railway was built to Drumheller. This brought people to work in the coal mines, which provided the economic basis of the Valley in the first half of the twentieth century. The Drumheller Valley population peaked at about 10,000 people in the early 1940s, when there were at least nine active coal mines. At this time,

---

[2]The Drumheller Valley squatters were, for the most part, coal miners who built their homes on land owned by the coal mining companies, the government or the railroad, mainly during the 1920s and 1930s. There are still 67 squatter families living on the Drumheller Valley flood plain, on land owned by the Alberta government, the City of Drumheller or private citizens. The Alberta Department of Municipal Affairs has been studying the squatter situation in the Drumheller Valley, but has yet to develop a policy to deal with the squatters.

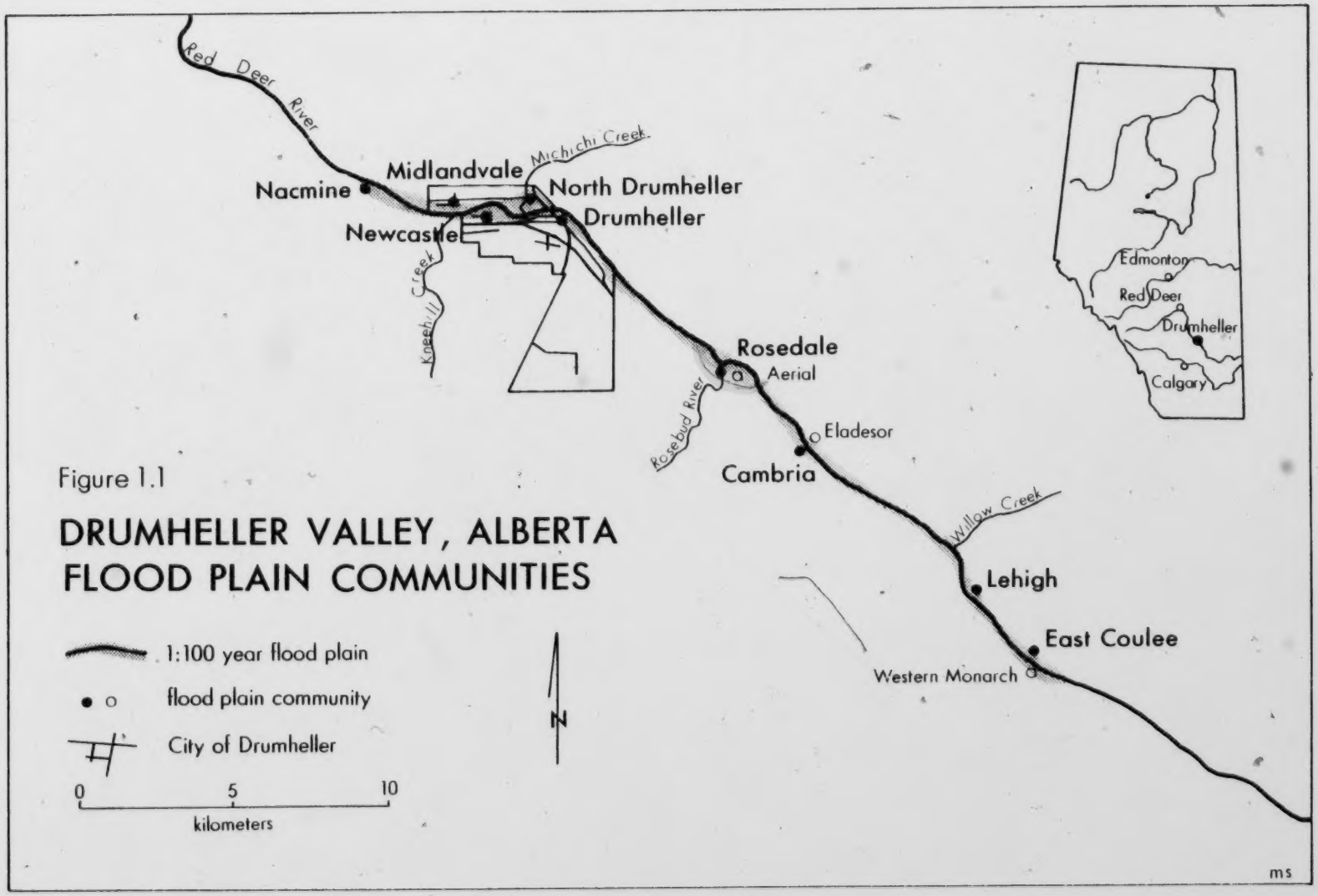

Figure 1.1

DRUMHELLER VALLEY, ALBERTA FLOOD PLAIN COMMUNITIES

the hamlet of East Coulee, which now has a population of 261, had a population of 3,000, approximately the same as the City of Drumheller (Fryer 1976, p.83). In the 1950s, most of the mines were closed as oil and gas replaced coal for locomotive, domestic and other purposes in Alberta. This caused the Drumheller Valley population to decline in the 1950s and early 1960s. However, the Drumheller Valley population has remained stable, at about 7,000, for the past decade (CRPC 1978, p.1-5). During the same period, the City of Drumheller population has increased from 5,365 to 5,888.[3] The 1978 Drumheller Valley flood plain population is estimated to 2,174, based on an average family size of 3.3 for I.D. No. 7 and 3.2 for the City of Drumheller (Statistics Canada 1976, pp.I-9, I-10). This is almost one third of the Drumheller Valley population.

The Atlas mine at East Coulee is the single remaining active coal mine. The City of Drumheller is the service center for neighboring agricultural regions. It is also the location of a federal penitentiary, built in 1970, which employs 350 people (Alberta, Department of Municipal Affairs 1977, pp.2-3). The hamlets, which were populated by coal miners, are now, for the most part, "bedroom communities" whose occupants work and shop in Drumheller.

1.3 Drumheller Valley Flood Adjustments

During previous Drumheller Valley floods, emergency action, evacuation and relief were used to cope with flood waters. According to local

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[3] According to the Canadian census, the City of Drumheller population increased from 3,574 in 1966 to 5,888 in 1971. This increase was due for the most part, to the annexation of Midlandvale, Newcastle and North Drumheller, which added 1,752 people to the City. A corresponding decrease in the I.D. No. 7 population figures was recorded for the same period (CRPC 1978, p.1-5).

insurance agents, flood insurance was available "years ago" (Rutz 1979; Sheddy 1979). Following a series of floods in the late 1940s and early 1950s, some buildings were flood proofed by sealing windows or raising new structures on earth fill. As a result of provincial efforts, the Drumheller Valley now has a program to cope with flooding through flood forecasting, emergency action and public relief. However, these measures have not been tested because there have been no floods in the Drumheller Valley since they were implemented. Moreover, once the Red Deer Dam is built, 240 km upstream, the Drumheller Valley may have some flood control. In addition, the new Alberta Planning Act (1977) provides the framework for implementing a flood plain land use policy. At the present time, a comprehensive flood plain management policy has not been adopted by either municipality.

In an attempt to reduce potential Drumheller Valley flood damages, the Alberta Department of the Environment, Planning Division has initiated the Drumheller Flood Control Study to identify and evaluate the feasibility of reducing flood damages in the Drumheller Valley (1979, p.1). This study has not been initiated in the wake of a flood disaster. Rather, it arose as a result of a political promise to provide flood protection for Drumheller Valley residents following construction of the Red Deer Dam. The eight study components are: topographical mapping, hydrology, land uses and regulation, hydraulics and flood plain mapping, flood damages, flood proofing, engineering costs and designs, and evaluation of alternative flood control options (Alberta, Department of Environment, Planning Division 1979, p.1). A portion of the information contained in this thesis and some additional material make up the "land uses and regulations" component of the Drumheller Valley

Flood Control Study (Staite 1979a, 1979b, 1979c).

Drumheller Valley residents have some input into the study through the Drumheller Valley Flood Control Advisory Committee (DVFCAC), which is made up of Alberta, Department of the Environment planners, PRPC staff representatives, the City of Drumheller Manager, the City of Drumheller Engineer, and several citizen representatives of Drumheller and I.D. No. 7. The four major functions of this committee are:

1. to provide liason between Drumheller Valley residents and Department of Environment personnel;
2. to identify the concerns of Valley residents with flood control and to make them aware of possible courses of action;
3. to suggest means of reducing flood damage or minimizing the negative effects of flood control from a community perspective; and
4. to assist in reviewing and evaluating all aspects of the study, to formulate recommendations and to decide how the works should be implemented (DVFCAC 1978a, p.1)

The Drumheller Flood Control Study is being guided and undertaken by the Flood Abatement Working Group (FAWG), which is composed of Alberta Department of the Environment employees[4], Klohn Leonoff Consultants[5], and the Director of the PRPC. FAWG will eventually evaluate alternative flood control measures, including the "land uses and land use regulations" and recommend a flood control program for the Drumheller Valley. It is anticipated that this will be complete by late 1979 or early 1980.

1.4 Purpose

In this thesis, alternative land use management policies and

---

[4]These include representatives from the Planning Division, Interdepartmental Relations Division, Operations and Maintenance Division, River Engineering Division, Water Resources Division and Design and Construction Division.

[5]Klohn Leonoff Consultants Limited has been contracted to conduct the majority of the research for the Drumheller Flood Control Study.

associated adjustments to reduce the Drumheller Valley flood hazard[6] are suggested and discussed. The alternatives are based on information derived from current flood plain management literature, reports of previous flooding and adjustments in the Drumheller Valley, an investigation of the present Alberta and Drumheller Valley flood plain management and flood adjustment policies and programs, a review of Alberta legislation and municipal bylaws affecting Drumheller Valley flood plain management, and a land use study of the Drumheller Valley flood plain.

The study methodology is outlined in the following chapter. Current North American flood plain literature is reviewed in the third chapter. Then, in the fourth chapter, past flooding and flood hazard adjustments in the Drumheller Valley are investigated. Chapter five is a discussion of the legal framework for general land use and flood plain management in Alberta and the Drumheller Valley. Alternative land use adjustments and potential effects are suggested and discussed for each of the ten Drumheller Valley communities in the sixth and seventh chapters. In the final chapter, the findings of the research are summarized, conclusions are drawn and recommendations for future research are made.

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[6] In this thesis, hazard is defined in terms of potential life and property damage which would result from a flood event.

CHAPTER II

METHODOLOGY

2.1 Introduction

The research is based on information obtained from five sources: a literature review, review of legislation and bylaws affecting Drumheller flood plain development, flood plain maps prepared for the Alberta Department of the Environment Planning Division by Klohn Leonoff Consultants Limited, a land use study of the Drumheller Valley flood plain, and meetings, communications and discussions with PRPC staff, Alberta Department of Environment Planners, engineers and consultants and the City of Drumheller and I.D. No. 7 staff.

2.2 Literature Review

North American literature in the field of flood plain management was reviewed. The findings are discussed in chapter three, within the natural hazards framework developed by Burton, Kates and White (1968). Government research reports and planning studies of the Red Deer River Basin and Drumheller Valley were studied. These are discussed in chapter four.

2.3 Legislation and Bylaws

Alberta legislation and the City of Drumheller and I.D. No. 7 development control bylaws related to flood plain development are reviewed in chapter five. Assistance was provided by the PRPC staff, particularly with the interpretation of the Planning Act (1977), the City of Drum-

heller Development Control Bylaw (1976) and the Improvement District No. 7 Development Control Bylaw, Directions in Force (1978). This act and these bylaws are the legal basis for the land use adjustments discussed in chapter six.

2.4 Flood Plain Delineation

The 1:100, 1:50 and 1:25 year flood plains, as determined by Klohn Leonoff Consultants Limited (forthcoming 1979), using streamflow data provided by the Alberta Department of the Environment and the HEC-2 computer program, without compensating for possible effects of the Red Deer Dam, provide the basis for discussion of the sixteen-kilometer long area of the flood plain from Nacmine to Cambria. These flood lines have been drawn on the flood plain maps (appendices B to G). Since the flood plain maps are not finished for the area from Cambria to East Coulee, the 1:100 year flood plain has been estimated by the author for this twelve-kilometer section. The estimated flood plain is drawn on the flood plain maps (appendix H). Based on air photo interpretation and field reconnaisance, it is anticipated that the 1:100 year flood plain is bounded by Number 10 Highway on the east from the Cambria bridge to East Coulee. The estimated flood plain boundary passes through the center of East Coulee, including 62 of the 138 buildings in the hamlet. This is approximately the area flooded by the 1948 flood, according to newspaper records (Calgary Herald, April 26, 1948).

When the singular term "flood plain" is used, it is in reference to the 1:100 year flood plain. In other instances, the recurrance interval is specified.

2.5 Land Use

Land use information, which forms part of the basis for discussion in chapters six and seven, was obtained from two sources: municipal property tax assessment forms and a field check of flood plain buildings and land uses undertaken in the autumn of 1978. This method was suggested by members of the Red Deer Regional Planning Commission who had recently completed a study of Sundre land use at the request of the Alberta Department of the Environment, Planning Division, prior to commencement of the Sundre flood protection program (Newman 1978). The following information was obtained from the tax assessment forms: owner, address, building use, building type, building class, building size, building structure, type of basement and assessed value. All buildings were field checked to verify use, type, condition, lowest water entry point and first floor height. Data were recorded on standard field sheets according to subdivision plan, block and lot number to facilitate mapping (appendix A).

Maps of the following factors were produced for each community at an original scale of 1:2,500, using base maps provided by the Alberta Department of Municipal Affairs: land use, land use zoning, building class and lowest water entry point. Reduced copies of the maps are contained in appendices B to H.[1]

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[1] It will be noted that the area mapped includes land outside of the 1:100 year flood plain. The Klohn Leonoff flood plain maps for the area from Nacmine to East Coulee had not been completed when the field work was conducted. At this time, the study area was based on an earlier flood plain map prepared by the Alberta Department of the Environment, Technical Services Division (1975). The area adjacent to the flood plain was mapped to allow for error.

The following data were tabulated for each community: land use, building age, building class, building condition and lowest water entry point. The data are included in the chapter six discussion of communities.

"Land use" information was based upon air photo interpretation and a field check of the Drumheller Valley flood plain. Categories and mapping symbols were adapted from De Chiara and Koppelman's "simplified set of land use categories" which were designed for rural areas or communities with non-intensive, simple use patterns (1969, p.9). "Land use zoning" information was based on the land use districts defined in the current City of Drumheller Development Control Bylaw (1976) and the Improvement District No. 7 Development Control Bylaw, Directions in Force (1978).

"Building class" information was obtained from the municipal tax assessment records. The classes are defined by the Alberta Department of Municipal Affairs (1967) and are standard throughout the province. The classification is based on a three-part alpha-numeric code, for example 3F3. The first number refers to the class of dwelling, for example one-storey or two-storey. The letter refers to the type of structure and includes consideration of the type of floors, walls, roof and size. This ranges from A to F. "A" refers to an excellent modern building and "F" refers to an old, poor building. In addition, "M" is used to delineate modular or mobile homes and "Q" is used to designate quonsets. The last number refers to whether or not the building has a basement. If there is no last number, there is a full basement; if there is a "3", there is a dugout or part basement. For mapping purposes, only the letter was used to denote building classification, since

it is very difficult to differentiate the number of symbols needed to portray all combinations of class, type and basement. Moreover, most buildings were only one-storey, and possible basement flooding is covered by the maps of "potential water entry points".

"Lowest potential water entry point" is based on the height above ground level in half-meter intervals, as estimated visually during the field check of flood plain land uses. The height of first floor and basement openings above ground level were recorded and mapped for all buildings on the Drumheller Valley flood plain.

"Building age" information is based on the information recorded on the municipal tax assessment cards. Owing to the lack of records for early settlement in the Valley, buildings constructed prior to 1940 were grouped into one category. The age of each building on the flood plain was recorded and mapped according to the decade in which it was constructed.

"Building condition" information is based on a subjective appraisal of exterior building upkeep and is not based on building age or type. The three categories "good", "fair" and "poor" are based on the criteria used by the CRPC in their assessment of Drumheller Valley housing condition (1978, appendix D). "Good" condition includes buildings in sound structural condition, free of deterioration, well maintained and of good original construction. "Fair" condition designated buildings if reasonably sound construction, but which present a neglected or run-down appearance due to lack of maintenance. "Poor" condition refers to buildings which display serious signs of structural deficencies which make necessary repairs uneconomical. While conducting the field study, the additional classes "fair to good" and "fair to poor" were

added for buildings intermediate to these categories.

In addition, information pertaining to "land ownership" and "assessed value" of the property was collected. These data were recorded primarily for the Alberta Department of the Environment and are not mapped or tabulated in the thesis. "Land ownership" information was obtained from the municipal property tax assessment forms retained at the City of Drumheller City Hall and the Alberta Department of Municipal Affairs, Improvement Administration office located in Edmonton. It is current to December, 1977. "Assessed value" is the assessed fair actual value of improvements to property, including the main structure and outbuildings, as determined by the municipal tax assessor. An estimate of the 1979 market value may be obtained by multiplying this value by seven. The building contents are worth approximately forty percent of the assessed value (Sydneysmith 1979).

2.6 Meetings with Planning Officials

During the course of the research, meetings were held with planners of various government agencies and private consulting firms. In August, 1978, conversation with the Alberta Department of the Environment Red Deer River Basin planners and members of the Red Deer Regional Planning Commission, who had recently completed a land use study of the Sundre flood plain, helped to establish the conceptual framework and the types and sources of land use data available (Hardie 1978; Hart 1978; Newman 1978). Members of the CRPC, who had prepared the Drumheller Valley General Plan (1977a), provided some information about Drumheller Valley land uses and the planning process (Sanderson 1978).

In September 1978, the City of Drumheller Manager and the City Engineer provided information about local planning problems and interpretation of the City of Drumheller Development Control Bylaw (1976). The Alberta Department of Municipal Affairs staff in Drumheller provided similar information about I.D. No. 7. A meeting of the Drumheller Valley Flood Plain Advisory Committee, which is composed of representatives of the Alberta Department of the Environment, the PRPC staff, the City of Drumheller staff, the Drumheller City Council and Drumheller Valley citizens, was attended in October, 1978 (DVFPAC 1978b).

In February, 1979, a meeting was held with the PRPC staff concerning interpretation of the Planning Act and the municipal bylaws. In addition, the PRPC director read and commented on two earlier drafts of chapter four.

In March, 1979, a meeting of the Drumheller Flood Abatement Working Group, which is made up of consultants, engineers and planners who are working on the Drumheller Flood Control Study was attended. At this meeting, the author gained additional insight into Drumheller Valley flood management problems.

CHAPTER III

A REVIEW OF FLOOD HAZARD ADJUSTMENT LITERATURE

3.1 Introduction

In the twenty years since natural hazards research commenced at the University of Chicago, Department of Geography, a large body of literature on flooding, human adjustments to the flood hazard and management policies for flood-prone land has emerged. White (1961, pp.23-40) introduced the concept that a property manager chooses an adjustment to the flood hazard from a wide range of theoretical and practical adjustments. He showed that in any situation there is a "theoretical range of choice" among a wide number of practiced or innovative alternatives and a "practical range of choice", which encompasses only those choices that are technically feasible and sociably acceptable. He suggested that in order to choose an adjustment, resource managers evaluate some or all of the following: the quantity or quality of the physical resource; present value of gains or losses arising from future use of the resource; technological change which may affect future demand, future production, and compatible use combinations; and the relation of any given use to other resource uses in contiguous or functionally related areas. This concept was modified by Kates (1962), who introduced the idea that evaluation and decisions are limited by man's bounded rationality. In 1968, Burton and others organized the range of theoretical adjustments to natural hazards into four categories: modify the cause, modify the hazard, modify the loss, and adjust to the loss. The model will be

used in this chapter as the framework for a general discussion of alternative flood plain management measures. In chapter four, it will provide the basis for discussion of Drumheller Valley flood hazard adjustments. Models used by other researchers will be discussed in the conclusion to this chapter.

The natural hazards model includes both structural and nonstructural measures in the theoretical range of choice. Numerous researchers differentiate between the structural and nonstructural measures (for example: James 1974; Dickey and Duncan 1976). Structural measures are the traditional flood control structures, such as dams, dykes, channelization projects and so forth, which change the actual river system. Nonstructural measures change the pattern of human response to hazard situations and include measures such as land use management, flood proofing and flood insurance (James 1974, p.2). The danger of differentiating between structural and nonstructural adjustments arises when these are considered to be alternatives or opposites, rather than complementary adjustments.

Part of the problem, in this regard, stems from the conceptualization of the problem by the flood plain manager. Frequently, the question is posed: "How can we control flooding?". This presupposes a structural solution to prevent further inundation of the flood plain.[1] If it is recognized that flooding is a natural phenomenon of all rivers,

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[1] An example of this is the current Drumheller Flood Control Study. The title of the study leaves one to assume that future flood damages will be controlled or eliminated. If the study is to be an investigation of alternative structural and nonstructural measures, its purpose should be to reduce the potential for future flood damages.

and no matter what level of protection is chosen, it is likely to be exceeded sometime in the future, the question becomes: "How can we minimize damage from flooding and still retain significant use of, or production from, the flood plain?". Only then, will the manager be in a position to consider not only flood control, but also a variety of structural and nonstructural adjustments.

Burton and others (1968, p.13) noted that the dichotomy between structural and nonstructural adjustments is frequently emphasized because it coincides with project funding. Structural solutions are commonly undertaken at public expense, while nonstructural adjustments are left to municipalities or private citizens. There is often strong pressure, which has political overtones, for adoption of technical solutions which shift the costs of flood plain occupance away from individuals to society at large.

> An obvious conclusion is the need to place the burden of costs for technical solutions on the shoulders of those who benefit and/or find ways of carrying out social adjustments partly at public expense through the use of subsidies, incentive payments and the like.
>
> (Burton et al. 1968, p.14)

In many cases, a mix of structural and nonstructural adjustments may provide the optimum alternative. This would be overlooked if nonstructural and structural measures were considered separately. Thus, the adjustments discussed below include both structural and nonstructural measures.

3.2 Alternative Flood Hazard Adjustments

3.2.1 The Range of Choice

The model developed by Burton and others (1968) has been used as the basis for identifying and discussing alternative adjustments to the flood hazard by natural hazards researchers (Saarinen 1969; Mitchell et al. 1978) and by planning agencies and consultants (U.S. Water Resources Council 1976; Dillon and MacLaren 1977) (Figure 3.1). The model is based on the concept that the natural hazard, in this case flooding, results from the interaction of natural events and the human system (Figure 3.2). The human system, which includes the norms, values and attitudes, which are influenced by social and political-institutional processes, sets the limits within which an adjustment or combination of adjustments to flooding are chosen from a range of alternatives. The choice of adjustment, in turn, creates a new social-environmental relationship. This new relationship between the natural and human systems feeds back into the system, modifying the future choice of adjustments to the hazard (White and Haas 1975, p.64). Thus, human adjustment to natural hazards, flooding in this instance, is an ongoing, dynamic process.

The theoretical range of human adjustments to the flood hazard has been divided into four categories: modify the cause, modify the hazard, modify the loss potential and adjust to the loss (Figure 3.1). Two methods of modifying the cause have been suggested: watershed management to maximize water retention storage and weather modification to control the timing and location of precipitation. The potential flood hazard can be modified by flood control projects such as reservoir, dykes or channelization projects. Emergency flood fighting, for example

Figure 3.1

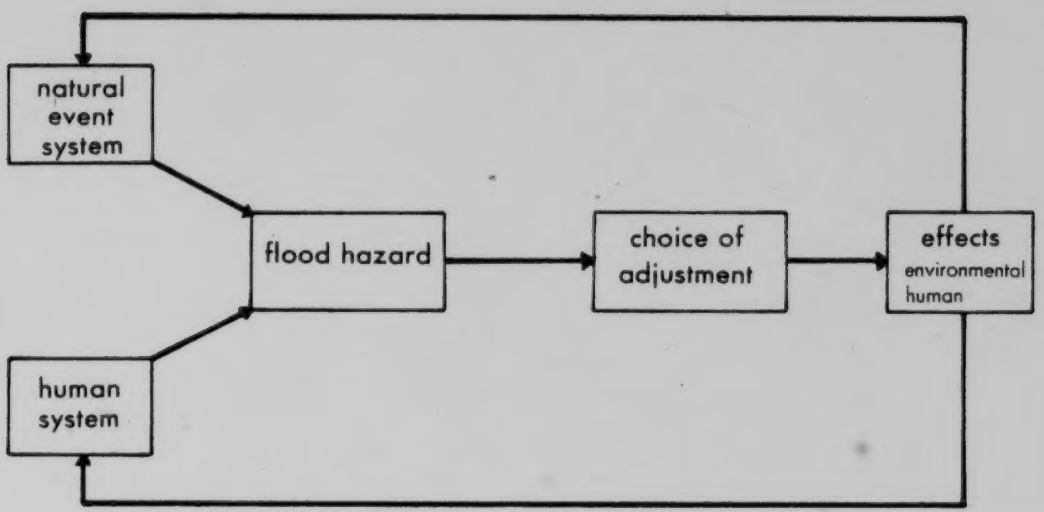
THEORETICAL RANGE OF ADJUSTMENTS TO THE FLOOD HAZARD

Modify the Cause	Modify the Hazard	Modify the Loss Potential	Adjust to the Loss		
			Spread the Loss	Plan for the Loss	Bear the Loss
watershed management	reservoirs	flood forecasting	subsidized insurance	private insurance	individual loss bearing
weather modification	dykes	flood proofing	public relief	reschedule production	
	channelization	emergency action	tax adjustments		
		land use management	public purchase		
		permanent evacuation			
		development policies			
		warning signs			
		public education			

Source: Adapted with modifications from: I.Burton et al., 1968; T.F.Saarinen, 1974; B.Mitchell et al., 1978.

Figure 3.2

SYSTEM OF FLOOD HAZARD ADJUSTMENTS AND EFFECTS



Source: G.White and J.E.Haas. 1975. p. 64

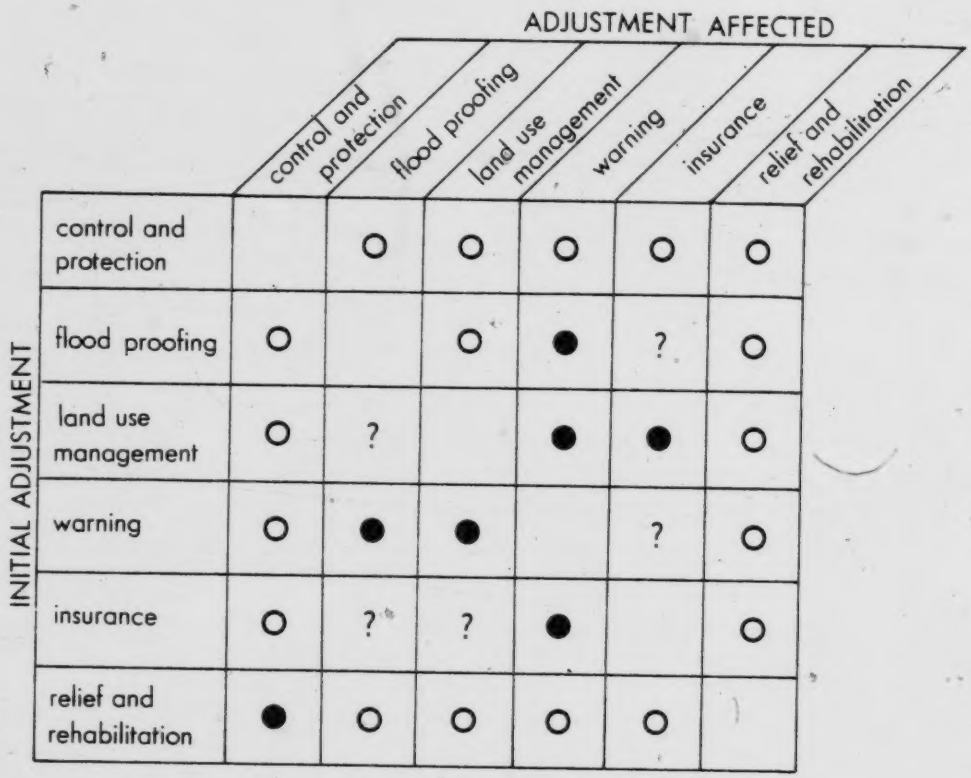
building temporary sandbag dykes during a flood event, would reduce flood damage, if there was sufficient warning. Potential flood-related losses can be modified through measures adopted in anticipation of flooding, such as flood proofing, land use management, public education and emergency plans. The occupants of flood plain land may adjust to flood-related losses by spreading the loss to society as a whole, by planning for the loss or by bearing the entire cost of the loss.

"Only a little is known about how one's choice of an adjustment encourages or inhibits choice of another" (White and Haas 1975, p.63). Research has shown that construction of upstream storage works frequently encourages people to move further on to the flood plain and that dykes may also promote a feeling of security and encourage people to locate on the flood plain (White et al. 1958). White (1975) suggested that adoption of an initial adjustment may stimulate future adoption of other adjustments in varying degrees (Figure 3.3). He considered the interaction between six adjustments: control and protection, flood proofing, land use planning, warnings, insurance, relief and rehabilitation, by showing how adoption of the initial adjustment may result in high, little or doubtful stimulation to adopt other adjustments.

> If a community adopts land use regulations in flooded areas, it is less likely to seek control and protection for the same area. On the other hand, field studies suggest that if a community has already benefited from a levee or upstream protection work, it shows less disposition to support land use regulations in the remaining vulnerable zones of the flood plain. Insurance coverage with annual payment of premiums may be expected to stimulate interest in warnings if there is a substantial deductible item. There is little experience and only weak theory upon which to base a judgment on the extent to which adoption of land use regulations inhibits or encourages flood proofing by owners of exposed buildings.
>
> (White and Haas 1975, p.65)

Figure 3.3

MATRIX OF INTERACTION OF ADJUSTMENTS TO FLOODS



INITIAL ADJUSTMENT \ ADJUSTMENT AFFECTED	control and protection	flood proofing	land use management	warning	insurance	relief and rehabilitation
control and protection		O	O	O	O	O
flood proofing	O		O	●	?	O
land use management	O	?		●	●	O
warning	O	●	●		?	O
insurance	O	?	?	●		O
relief and rehabilitation	●	O	O	O	O	

stimulation by initial adjustment:

● high

O little

? doubtful

Source: Adapted with modifications from: G.White and J.E.Haas. 1975. p.65.

Thus, it must be recognized that action taken with respect to one adjustment may affect the type of response society will make to any other adjustment. For example implementation of a flood protection scheme may discourage flood plain occupants from adopting flood proofing. White (1979) noted that the United States government anticipated that adoption of flood insurance would encourage municipalities to enact land use regulations. However, owing to the limited municipal expertise and lack of state and federal guidance, success in this regard has been mediocre. In any situation, the interrelationships among alternatives are dynamic and will change over time. White and Haas (1975) noted that more research is needed in this field, if researchers and policy makers are to understand the "profound effects" adoption of one adjustment may have on the kind of response which society makes to other adjustments.

A review of natural hazards and other literature relating to flooding identified seventeen possible adjustments to flooding. These are discussed below by using the theoretical range of adjustments to natural hazards as a framework. Although each alternative is discussed separately, none, in itself, is a solution to flood protection. Interrelationships will be discussed when they have been documented in the literature.

3.2.2 Modify the Cause

River flooding occurs when streamflow exceeds channel capacity; it is considered to be a natural hazard when human life and property are endangered. Major floods are generally the result of sustained periods of rainfall, which may be coupled with rapid snowmelt (Boring 1969, p.15). This is most easily understood using the water balance equation:

$$Q = P - E \pm \Delta S$$

where: Q = discharge
P = precipitation
E = evaporation/evapotranspiration
S = storage (soil moisture, groundwater, depression and snowpack)

(Gregory and Walling 1978, p.189)

Intense rainfall may exceed potential evapotranspiration and available storage, especially in spring, when potential evapotranspiration is low and soil moisture is at storage capacity. Stream discharge will increase and flooding may occur. Thus, two methods to reduce the cause of flooding are suggested: watershed management and weather modification.

a) Watershed Management

Although river flooding is a natural phenomenon, man may exacerbate the flood peak through vegetation removal, wetland drainage, stream channelization and "waterproofing" urban land. These measures reduce soil moisture storage capacity, evapotranspiration and moisture interception by vegetation. Also, man may cause flooding through miscalculation of reservoir operation, as in the 1974 Grand River (Ontario) flood, when extreme rainfall, high antecedent soil moisture conditions and simultaneous flood crests on tributary rivers combined to cause high reservoir levels. The necessary release of stored water and the floodwaters which followed caused the most damaging flood in the history of the Grand River basin (Mitchell et al. 1978, p.27).

A watershed management program may be designed to increase water storage, interception and potential evapotranspiration by increasing soil moisture, groundwater, depressional or snowpack storage and/or maintaining or selecting vegetation cover to intercept moisture and to

increase evapotranspiration. These measures would increase the time for runoff to reach the stream and reduce the flood peak. Research has shown that peak runoff and water yield may be increased by forestry practices, agricultural practices and urban development (Periera 1973, p. 167; Galbraith 1975, p.169; Darby and Small 1976, p. 349; Swanson and Hillman 1977, p. 267; Warwick 1978, p.26). Watershed management techniques in these situations would involve measures to increase moisture storage and recharge, such as by reforestation and selective cutting in forestry operation, controlling slough and wetland drainage in agricultural areas and detention storage improvement in urban areas.

b) Weather Modification

Several authors have suggested that weather modification could alleviate potential flood disasters (Phippen 1970; Jevdjevich 1974; Saarinen 1974; Mitchell et al. 1978). By seeding clouds of a potentially catastrophic rainstorm, it is anticipated that rain could be induced prior to reaching heavily urbanized drainage basins or that the rainfall could be dissipated. Presently, weather modification is a theoretical adjustment, limited by man's ability to predict and control the weather. Mitchell and others noted that even if it were possible to manipulate weather systems, there are inherent problems. The suppression of intense rainfall or initiation of precipitation by cloud seeding may cause problems for adjacent areas which may be more undesirable than the original one (Mitchell et al. 1978, p.50). Moreover, the physical potential for weather modification is most promising for inducing orographic rainfall, as opposed to cyclonic or convectional rainfall. Generally, the most intense rainfall in Alberta is associated

with cyclonic storms.

Thus, man's ability to control the causes of flooding is limited by his ability to modify the water balance. Presently, man's capability for weather modification is limited; however, man can utilize and manage the land, bearing in mind the need to reduce surface runoff and improve detention storage.

3.2.3 Modify the Hazard

Adjustments which modify the flood hazard are the structural flood control measures: reservoirs, dykes and channelization projects. Reservoirs provide storage for peak streamflow and release the stored water slowly, thereby dissipating the flood peak. If used solely for flood control purposes, reservoirs provide protection to the design flood capacity. Frequently, as is the case for the Red Deer Dam, reservoirs are constructed for multiple purposes, such as hydro power, recreation and water supply, which may receive higher priority than flood control. In the event of a design flood, storage sufficient to retain peak flows may not be available and downstream flooding may occur. Dykes contain a given frequency stream stage. Events exceeding the design height will inundate the area being protected unless dyke heights are raised by emergency sandbagging or other means. In addition, local rainfall may be trapped behind the dykes and cause flooding. Channelization increases channel capacity to contain a design-flood volume, thus providing protection to this level. A stream diversion or a floodway bypass may provide an alternate channel for floodwaters which may endanger an urban area. If well-maintained, a diversion may significantly reduce potential flood damage, as in the 1974 and 1979 Winnipeg floods (Rich 1974;

Edmonton Journal, May 8 and May 12, 1979).

Government funding of flood control measures places the costs to protect flood plain occupants on society as a whole (Burton et al. 1968, p.14).

> Numerous authors have argued that the "best mix" of resource management policies will be adopted only when we tie the beneficieries of the program to the costs of the program... Resources policies subsidize one distinguishable group of people at the expense of the general public treasury.
>
> (Shabman and Damianos 1976, p.151)

Burton and others (1968, p.14) indicated that the "obvious solution is to place the burden of costs for technical solutions on the shoulders of those who benefit" or to find ways of "carrying out social solutions partly at public expense" through subsidies or incentive payments.

Until recently, the flood hazard in the United States, Canada and throughout most of the world has been treated only after a disaster by offering immediate relief followed by a technical solution (Saarinen 1974, p.273). In the mid-1960's, the United States government recognized that although billions of dollars had been spent on flood control programs, damages attributable to inundation continued to increase; in Canada, the federal government recognized a similar, although less costly, trend. In response, the United States government adopted a Unified National Program for Flood Plain Management (U.S. Water Resources Council 1976) and the Canadian government adopted The National Flood Damage Reduction Program (Bruce et al. 1977). Both programs are based on the recognition that structural means have played, and will continue to play, an important role in alleviating potential flood damages, and that flood control structures, alone, have limited effectiveness and should be implemented in conjunction with other adjustments. This point was under-

scored by Phippen:

> The case made here for flood control should not be taken to mean that it is sufficient for flood plain management, but rather to indicate the role which it has played and will continue to play in the future. While individual flood control projects have performed effectively, it must be recognized that the nation's losses have continued to increase. The substantial collective effect of works has not proven a satisfactory solution to an expanding problem.
>
> (Phippen 1970, p.644)

In summary, although structures are effective in controlling design floods, events beyond the design-magnitude can result in catastrophe if other "backup" measures are not taken (Goddard 1976, p.87). Moreover, flood control structures tend to give flood plain residents a false sense of security (White et al. 1958; Sewell 1969, p. 441) and may encourage encroachment onto the flood plain (U.S. Water Resources Council 1976, p.II-2). The decision to adopt flood control structures is frequently reactionary, being made in the wake of a disaster. Because flood control construction is often government funded, flood control programs have a tendancy to be politically motivated and may not provide the best solution to the flooding problem. Furthermore, government construction of control works transfers the responsibility and cost from flood plain occupants to the public at large. "The fact that overall costs may thereby be increased does not appear to act as a deterrant" (Burton et al. 1968, p.14). Nevertheless, flood control works do provide a degree of protection from flooding, which can be increased through adoption of supplementary adjustments such as land use regulation, flood proofing, flood forecasting and flood insurance (James 1974, p.1).

3.2.4 Modify the Loss Potential

If the government and flood plain occupants are aware of the flood hazard, measures can be adopted to modify or reduce the flood loss potential by planning for emergency action and by using flood plain land in a manner compatable with the flood hazard. These measures may be used singly, but are more effective if implemented in combination, or in conjunction with structural measures.

a) Flood Forecasting

Flood forecasting is a prerequisite for emergency action. However, to be effective, there must be a close link between the agency issuing the flood warning and the affected community. Forecasting is most effective in large drainage basins where there is adequate time for emergency preparations. It is generally unsuitable for flash floods in small drainage basins (Goddard 1976, p.92).

Flood forecasting can involve two event types: rainfall and rainfall-snowmelt. In both situations, knowledge of moisture storage conditions and predicted rainfall is required in order to forecast flood probabilities. However, in snow situations, there is a much greater long-term forecast potential for both large and small basins. In Alberta, spring runoff forecasts are generally based upon snow depth, without adequate allowance for prior fall soil moisture storage. Thus, the 1974 floods, for example, were not adequately forecast (Laycock 1974).

There has been no systematic attempt to evaluate the benefits of a flood warning system (Kaul *et al*. 1974, p.15), despite the broad

application of flood warning systems in both the United States and Canada.[2] Day (1969, 1976) has done some preliminary research in this area. In 1969, Day and others considered the benefits due to warning as the reduction in damages attributable to the flood warning. Net benefits were calculated as the difference between expected damages with a warning and damages without it. It was shown that benefits vary in accordance with flood plain development. Day and Lee (1976) examined the "Flood Damage Reduction Potential of River Forecast" in the Connecticut River Basin. They estimated that the average annual basin-wide flood damage costs were approximately equal to the costs of the warning service and the community response system. They concluded that flood forecasting can result in substantial savings, only if flood plain occupants respond to the warning, and that response effectiveness is dependent on local preparation and communication. This was reinforced by Sniedovich and Davis (1977), who developed a system for evaluating response to flood forecasts. They found that the relative effectiveness of flood forecasting was dependent on the response strategy chosen by the flood plain dweller (p.95). Thus, a flood warning system is reliant on public preparation and awareness, which could be achieved through a public education program.

b) Flood Proofing

Sheaffer conducted the pioneer research into flood proofing: "a

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[2] In the United States, official forecasts and flood warnings are issued by the National Weather Service. In Canada, flood forecasting is administered by the provinces; Alberta flood forecasts are made by the Alberta Department of the Environment, as is discussed in chapter four (section 4.3.1).

body of adjustments to structures and building contents which are designed or adapted primarily to reduce flood damage" (1960, p.3). In 1976, this definition was broadened by the United States Department of Housing and Urban Development to include:

> any combination of structural and nonstructural additions, changes or adjustments to structures which reduce or eliminate flood damage to real estate, or improved real property, water and sanitary facilities, and their contents.

Flood proofing measures may be used to ensure that a structure is permanently prepared for a flood or may be a combination of structural change and emergency actions (Sewell 1969, p.436).

Sheaffer (1960, p.3) divided flood proofing methods into three categories:

1. permanent measures which provide permanent protection and do not depend on flood forecast judgement or action to be put into effect;
2. contingent measures which rely on forecast or warnings to be put into operation; and
3. emergency measures which are improvised and carried out during an emergency according to plans.

James F. MacLaren Limited (1978, p.3-1) noted that flood proofing can be corrective, when applied to existing structures, or preventive when applied to new buildings.

> Flood proofing is an adjustment that can be applied to both new and old structures, recognizing that in many instances flood proofing of an old structure may be extremely difficult, expensive or not even feasible. Many of the adjustments that can be used for new construction would be impractical for existing construction. Flood proofing techniques are limited only to the ingenuity of the designer preparing the proposal.
>
> (Lardieri 1975, p.1155)

James F. MacLaren Limited (1978) discussed five categories of flood proofing: elevation with fill, elevation with columns, closures and seals, walls and berms, and wet flood proofing. Elevation using earth

fill provides permanent, dry flood proofing and requires no human involvement for protection to the design flood level. The major disadvantage is that large additions of fill displace water storage on the flood plain and may cause backwater flooding or may increase the height of the design flood. However, this disadvantage may be eliminated if filling is conducted as part of a predetermined strategy in a two-zone flood plain land use management concept (James F. MacLaren Limited 1978, p.3-2). Elevation on columns raises structures above the flood level without decreasing flood plain water storage capacity and raising of flood stages. However, columns are more susceptible to damage by ice and debris. The greatest potential for application of closures and seals is to non-residential structures. Generally, residential structures have insufficient strength to withstand large flood loads. Even if bulkheads and covers are carefully installed, the basic structure will crack under the pressure of the water. It is possible to design new small buildings to withstand water pressures; however, it is usually easier to design additional strength into new larger buildings.

> Perhaps the greatest problem with closures and seals is associated with the potential for catastrophic loss arising from overtopping the closures. If a three-foot closure is overtopped by even an inch, the interior of the structure will be flooded to a three-foot depth. On the other hand, if a house raised on three feet of fill is the site of a flood slightly greater than three feet, the house will receive only minimal damage.
>
> (James F. MacLaren Limited 1978, p.3-5)

Construction of walls and berms around a structure is essentially a form of dyking and has the advantage of protecting both the site and the structure from flood waters. However, they have the associated problems of catastrophic losses if overtopped and of displacement of

flood waters. Wet flood proofing maintains the structural integrity of a building by introducing either potable or flood water into the building. The obvious disadvantage is that the interior and contents are inundated. Although the structure may be maintained, it may not be liveable because of dampness or odors.

There have been several studies of the economic feasibility of flood proofing. James (1965) found it to be economically justified in situations involving low-density urban development and frequent flooding; maximum urban development within the flood plain for economic flood proofing was found to be ten percent. McKeever (1976) found that flood proofing was most effective for industrial flood damage reduction due to the availability of resources and manpower for implementation. He also noted that flood proofing could be useful for existing commercial establishments in conjunction with flood warnings, and would be least desirable for residential protection, especially in areas of flash flooding (p.121). James F. MacLaren Limited stated that "considerable benefit has been realized with surprisingly low costs for flood proofing" (1978, p.1-4) and cited two studies to justify this point (Athens 1964; Jones 1977). According to MacLaren, the Athens study reported a benefit cost ratio of 5:1 in favor of flood proofing and the Jones study reported "wet" flood proofing, at a cost of $550 during building construction reduced damage from inundation by eighty percent.

In the United States, federal legislation has provided incentives for flood proofing adoption. Although the National Flood Insurance Act (1968) did not specifically mention flood proofing, it offered subsidized insurance contingent upon proper flood plain management; the use of flood proofing was encouraged through the efforts of the U.S. Army Corps

of Engineers (James F. MacLaren 1978, p.2-2). The Flood Disaster Protection Act (1973) contained incentives to purchase flood insurance; the rate structure was sensitive to the potential effects of flood proofing on flood losses. The revised National Flood Insurance Program of 1976 defined flood proofing in the program; and the Federal Insurance Administration will insure structures are elevated above the 1:100 year flood level. Thus, in the United States there has been much research and testing in the field of flood proofing.

In Canada, there has been far less research and application of flood proofing techniques. A questionnaire sent to 125 Canadian municipalities in 1977, including the City of Drumheller, met with a fifty percent response rate. It was found that Canadian provinces and municipalities had little experience with flood proofing applications and feasibility determinations. This was attributed to an absence of a continuous education and training program and to the fact that Canadian legislation provides few incentives for flood proofing (James F. MacLaren 1978, p.2-17). Two reasons for this were noted. First, the popularity of the one-zone concept of flood plain management prohibits new buildings on the entire flood plain (as opposed to the two-zone concept which allows flood-proofed development in fringe areas). Second, in Canada, development of properly flood-proofed buildings is not encouraged by a national flood insurance program. Nevertheless, it was concluded that despite the fact that flood proofing has not been implemented on a wide scale in Canada, Canadian municipalities are interested in flood proofing, since many requested information on the topic.

c) Emergency Action

Emergency action is undertaken during a flood to reduce flood losses, and it includes temporary evacuation and flood fighting. It is one of the oldest nonstructural measures (Goddard 1976, p.91). Effectiveness is dependent on prior preparation for the emergency and sufficient warning to allow implementation. Some communities, such as those along the Mississippi River, rely almost exclusively on evacuation to cope with annual flooding (Sewell 1969, p.434). Sometimes evacuation is undertaken by individuals, but frequently overall responsibility is assumed by local or central government officials. Flood fighting measures may entail building temporary dykes or protecting equipment and structures using plastic sheeting and grease.

Sewell stated that emergency action can reduce flood losses; however, it is not a panacea. It is most effective when flood duration is short, flood velocity is low and flood frequency is high.

> Interest in emergency action tends to lag when the interval between floods is long. Its success hinges upon flood plain occupants being able to select the appropriate adjustment. There is evidence that flood plain occupants are not able to do so efficiently. Moreover, there is sometimes resistance to taking any action even though a flood warning has been issued.
>
> (Sewell 1969, p.435)

An emergency program would be most effective if implemented in conjunction with other adjustments such as flood forecasting, flood proofing, land use adjustments and a public education program.

In both Canada and the United States, development of emergency flood preparations is a community responsibility. In Canada, communities may be offered guidance by provincial government agencies, such as Alberta Disaster Services in Alberta. In the United States, the National

Weather Service has prepared a guide to "assist development of flood preparedness plans at the community level" (Owen 1976). However, Howells noted that no United States community had an adequate warning system encompassing forecast, dissemination of the forecast and preparation of the community to respond to the forecast (Howells 1977, p. 209). There has been no research to assess the adequacy of the Canadian and Albertan flood emergency preparedness programs.

d) Land Use Management

Flood plain land use controls may be adopted by municipal governments to regulate flood plain development and reduce potential flood damages:

> ...while the principal objective of flood plain management is the allocation of land to its most appropriate use from the viewpoint of the community as a whole, the nature and degree of occupancy should also be compatable with the risk factor involved.
>
> (M.M. Dillon Limited and James F. MacLaren Limited 1976, p.9)

Thus, both the Canadian Flood Damage Reduction Program, which Alberta has not yet joined, and the United States Unified National Program for Reducing Flood Losses are directed towards encouraging municipal governments to adopt flood plain land use management guidelines. In order for these programs to be effective, it is necessary that the public understand the general flood problem, the degree of risk and the methods that can be used to manage the land (U.S. Army Corps of Engineers 1967, p.3).

Man has an affinity for settling in fertile, low-lying valleys, close to drinking water supplies, irrigation reserves, livestock

watering supplies and river transportation routes (Sewell 1969, p.431; James F. MacLaren Limited 1978, p.1-1). However, there are benefits and costs of flood plain occupance. Flood plain sites may offer aesthetic, emotional or habitual attractiveness for residential occupation or may offer economic attractiveness for commercial or industrial developments, such as water supply or transportation. The costs involve property and infrastructure damages, lives lost and psychological traumas.

Sewell stated that potential flood losses vary with land use type, being highest on urban land, lower on recreation land and minimal on unused land. Although this may lead to the conclusion that all development should be kept out of the flood plain, this "would neither be realistic nor necessarily the economically most sensible course of action". In some cases, the economic advantages of flood plain location are greater than the potential losses. Sewell emphasized that flood plain regulation, which encourages potential occupants to consider flood costs, would encourage them to consider locating out of the flood plain (1969, p.436).

Most literature on this topic has emphasized the role of urban communities in the adoption of flood plain land use regulations. However, in 1973, Goddard estimated that forty-four percent of United States flood damages were to urban property and fifty-six percent were to rural property. There has been comparatively little research into rural flood adjustments; however, it would appear that land use regulation would be potentially useful here, particularly in rural areas adjacent to urban centers. White and Haas (1975, p.263) noted that land use regulation has the greatest potential for reducing urban expansion into flood plains, and that to be effective, land use regulation would

would need to prevent eighty to ninety percent of the uneconomic part of this expansion.

There are three inherent problems in introducing a flood plain management program. First, there is still considerable debate about what constitutes the flood plain. Second, it is difficult to reduce and remove flood plain development in existing urban areas. Third, land use controls are generally adopted by local governments. Many are reluctant to do so, especially if neighboring municipalities have not, for fear of discouraging potential investment or of weakening the tax base.

In the United States and most parts of Canada, the flood plain is defined as the area that would be inundated by the 1:100 year flood or the regional flood, based on the existing hydrologic record. In the United States, the Federal Insurance Administration will insure a building against flood damage if it is elevated on fill or columns to a level equal to the 1:100 year flood. The U.S. Army Corps of Engineers developed the concept of the floodway and the floodway fringe, a concept used in many states. The former is the main channel and adjacent area which would carry peak flow of an observable velocity during a 1:100 year flood; the latter would be inundated by slackwater. According to the U.S. Army Corps of Engineers, the floodway should be designated as open space or used for agriculture, recreation, parking or storage; the floodway fringe should be developed only if structures are raised on fill or flood proofed to the 1:100 year flood level (1967, p.7; Dougal 1969).

The Canadian Flood Damage Reduction Program has also incorporated the two-zone flood plain approach. Flood risk areas are mapped on the

basis of a design flood, which is not to be less than the 1:100 year event. However, if an inordinate amount of land would be excluded from development using this single flood plain, the floodway-floodway fringe concept may be employed (Bruce et al. 1977, p.58). In Ontario, where virtually all development has been restricted from the regional flood plain since Hurricane Hazel in 1954, use of a two-zone flood plain is under study (M.M. Dillon and James F. MacLaren Limited 1976).

It is necessary to recognize that predictions of floods of different recurrence intervals are the products of statistical analysis, based on the available data from the river basin in question. "We have to acknowledge that the base for our predictions is small and that man's actions in the use of land and natural changes may be undermining the limited base for predictions that we have". For example, the Susquehanna Basin, in the United States, is protected from a 1:100 year flood; however, a 1:400 year flood was experienced in 1972. Similarly, parts of North Dakota experienced four 1:100 year floods in one year, 1968 (Clarke 1978, p.228-9).

Recently, the use of the 1:100 year flood plain has been questioned. Dingman and Platt (1977, p.522) asked whether precise delineation of the 1:100 year flood plain is "practically desirable or legally necessary". They noted that because of the high cost of standard methods and the length of time involved, adoption of flood plain regulations is delayed and encroachment onto the flood plain continues.[3] They argued that

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[3] Dingman and Platt (1977, p.522) estimated that the average cost of flood plain mapping for a community is $36,000. Similarly, the Canadian government has budgeted approximately $33,000 per community for flood plain mapping projects in Saskatchewan (Canada, Department of Fisheries and Environment 1978c, p.11). Neither indicated the size of an average community.

more expedient, less precise methods are essential. On the other hand, McCrory and others (1976, p.196) stated that the 1:100 year flood plain does not treat all occupants equitably. They pointed out that much of the property on the 1:100 year urban flood plain is not exposed to excessive damage and that land use regulations that would prevent all future development would, in all probability, cost much more in terms of the lost opportunity value of the land than the benefit in terms of flood damages prevented. Therefore, they argued that flood plain development should be regulated on the basis of expected average annual damages. They recognized that this method would encounter opposition from those employing frequency criterion and concluded that the two methods could be used together to provide flexible planning (p.208). Buehler (1977, pp.329-30) argued that this concept of varying flood plain criterion is too complex and promotes greater flood plain development. Nevertheless, most land use studies and regulations in North America are based on the 1:100 year flood plain.

Municipalities generally control land uses and, thus, are the key government level to implement flood plain management. Municipalities have three general means for implementation of flood plain management: subdivision regulation, zoning regulations and building codes.[4] Subdivision regulations provide the means for controlling construction in undeveloped flood plain areas. Land use zoning allows designation of land uses compatable with the flood hazard. Building codes can be used

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[4]Municipal management of flood plain development in the Drumheller Valley is discussed in more detail in chapter five.

to set standards for flood plain construction. Other government levels can provide incentives to municipalities to adopt land use controls, such as the United States insurance program or funding subsidies, but decisions are made at the local level. Many municipalities are reluctant to adopt restrictive zoning bylaws or building codes, especially if flooding has not occurred recently.

Flood plain land use management is likely to be more effective in keeping new development out of flood plains, than in causing relocation of existing uses. An optimistic estimate for the rate of building removal from the flood plain is three percent per annum, "but methods for doing this and the possible influence of subsidies and tax incentives remain to be determined" (White and Haas 1975, p.263).

Enactment of land use controls compatable with the flood hazard is most likely to occur following a flood event. At this time, municipal governments are aware of the flood hazard, and if damage has been severe, they may redevelop the inundated area to conform to the flood hazard. However, White noted that, even following a disaster, there is a tendency on the part of communities to "rebuild" in the same location, particularly if public relief is provided (1979). Thus, if the government provides disaster relief, it should also provide financial incentives for people to move out of the hazard area.

e) Permanent Evacuation

Permanent evacuation or relocation of residences, industrial and commercial establishments will reduce potential flood damages. Most frequently, individuals evacuate the hazard following a major flood on an *ad hoc* basis. For example, Mitchell and others (1978, p.81) found

that:

> [t]hose individuals who sustain flood damages frequently try to sell their property at whatever market price can be negotiated, as evidenced by the number of 'For Sale" signs posted in Bridgeport succeeding the 1974 flood. Those structures that become vacant are usually associated with land acquisition programs such as that in Bridgeport and that which is in progress in Galt.

They concluded that permanent evacuation of the flood plain may be appropriate in certain areas and warrants further investigation.

Permanent evacuation is best-suited to individual residences. In fact evacuation of industrial and commercial establishments is often impossible due to the large capital investment (McKeever 1976, p.121). Also, industrial facilities may be located on the flood plain for a functional reason. In this case, flood proofing would provide a more viable alternative.

f) Development Policies

In conjunction with flood plain land use management, local governments may direct the installation of new utilities and services away from the flood plain. This would deter future flood plain development, since, generally the direction of urbanization is related closely to utility networks (Phippen 1970, p.643). In addition, if schools and other public buildings were located away from the flood plain, the municipality would provide community leadership for keeping development away from flood-prone areas (U.S. Army Corps of Engineers 1967, p.4).

In this context, the Canadian government has adopted several policies and incentives to discourage flood plain development: new federal buildings are located outside of the flood plain, Central Mortgage and Housing Corporation and the Department for Regional Economic Expansion

will not give financial assistance for undertakings in designated flood risk areas and flood disaster aid for further development is discontinued once a flood risk area has been defined and publicized (Bruce et al. 1977, p.61).

g) Warning Signs

Warning signs could be posted by the government to make the public aware of the flood plain location (Jevdjevich 1974). This could encourage flood plain occupants to adopt flood proofing measures and preparedness plans in anticipation of the hazard. It could also serve to alert prospective purchasers of flood plain land about the hazard.

h) Public Education

By improving the awareness of flood plain property owners to the potential flood hazard and to the types of individual adjustments that are available to mitigate the hazard, potential damages can be reduced (Phippen 1970; Jevdjevich 1974). In 1977, when a questionnaire was sent to Canadian municipalities, it was found that the majority of flood plain managers were not aware of the flood hazard in their area and, consequently, were not aware of flood proofing techniques (James F. MacLaren Limited 1978, p.6-4). Thus, if alternative flood hazard adjustments are to be considered in Canada and in Alberta, there is a need for public education, both at the administrative level and at the level of developers and flood plain occupants.

3.2.5 Adjust to the Loss

Flood losses can be spread to society as a whole, anticipated and partially paid in advance or completely borne by the affected persons. Subsidized insurance, public relief, tax adjustments and public land purchase are adjustments which spread at least part of the costs of flood losses to society as a whole. Private insurance and rescheduling production are adjustments utilized by the flood plain occupant to plan for the loss. In very few instances does the individual bear the entire cost of the losses caused by flooding; there is a tendency in North American society for these costs to borne by society as a whole.

a) Subsidized Insurance

Private insurance companies are generally reluctant to underwrite flood insurance because of the high degree of risk involved. Sewell (1969) noted that flood insurance, in itself, would tend to encourage increased flood plain occupance; however, only those flood plain occupants who could afford the premiums would remain or locate on the flood plain. If insurance is implemented in conjunction with flood proofing, land use controls and an effective warning and emergency preparation program, it may be effective in making occupants aware of the hazard and in encouraging individuals to plan for the loss. Even if insurance is subsidized, flood plain occupants would contribute to the cost of rehabilitation.

The United States government introduced the National Flood Insurance Act (1968) in response to the recommendation of the Task Force on Federal Flood Control Policy. Flood insurance was made available to vulnerable

areas under the condition that land use regulations to prohibit future unwise flood plain uses were adopted. Only flood victims who had purchased insurance qualified for relief payments. Federal house mortgages would only be allowed for insured flood plain dwellings. The Flood Disaster Protection Act (1973) had incentives for the purchase of insurance, especially through flood proofing. The National Insurance Program had four goals:

1. distribution of the cost burden more equitably among those who would be protected by insurance and the general public;
2. encourage state and local governments to adopt appropriate land use laws for flood-prone areas;
3. guide future construction away from the flood plain; and
4. assure that federal assistance to insurance would be coordinated with other federal flood-related programs.

(Loughlin 1971)

In 1976, the program was revised to consider only buildings flood proofed to the 1:100 year flood level as insurable. More specifically, residential structures must be raised above the 1:100 year flood line on pillars or fill. Industrial buildings may have closures or seals (James F. MacLaren Limited 1978, p.2-3). The program has been implemented in two stages. First, the emergency program, which subsidizes all rates is operative until a detailed study of the flood prone area is available. Second, the regular program is undertaken when the detailed study is complete and a flood insurance map is published. Structures which already existed on the flood plain are charged subsidized rates and new structures, substantially improved structures and structures which have suffered substantial flood damages are charged actuarial rates, which reflect the expected annual average flood loss.

Muckleston (1976, p.56) identified some of the advantages and disadvantages of the National Flood Insurance Program. The former are: community planners and administrators address flood-related problems; standards are set for land use and building codes; unnecessary flood plain use is discouraged by charging occupants for flood insurance; new and existing uses are differentiated by subsidizing the former and charging true rates to the latter; and flood victims are reimbursed more quickly and fully than they would be through federal relief programs. The disadvantages are: catastrophic losses may occur from floods exceeding the designated level; land use regulation implementation is not supervised by the federal government; providing flood insurance may encourage lending institutions to support construction they had previously considered too risky.

White (1979) noted that the United States flood insurance scheme has not been as successful as originally anticipated because insurance did not provide the predicted inducement for communities to adopt land use plans. He noted that although numerous communities have adopted land use plans "in spirit", in fact, insurance has not attained the anticipated goals. He stated that flood plain management, flood proofing and insurance policies should be combined in community plans, and that it is not sufficient to hope that promotion of insurance will result in adoption of the other adjustments. He concluded that long-term community planning, aided by the federal government, is necessary if the flood insurance program is to work, and if flood damages are to be reduced.

There is not a subsidized insurance program in Canada or the provinces (M.M. Dillon Limited and James F. MacLaren Limited 1976; Mitchell

et al. 1978). Bruce and others (1977, p.58) stated that subsidized flood insurance in Canada is an unsuitable adjustment because it is "simply another means by which the general taxpayer subsidizes development for the few on the flood plains" and it will not lessen the occurence of flood damages. Nevertheless, depending upon the success of the United States flood insurance program, this adjustment may warrant further investigation in Canada.

b) Public Relief

Public relief is one of the most common adjustments adopted in the wake of a flood disaster. Relief funds may be purely voluntary and may involve contributions from neighboring communities, the country or overseas. They may be granted by volunteer organizations such as the Red Cross or may be collected by community groups in the wake of a flood disaster. Public relief may also be provided by government organizations such as the Canadian Emergency Protection Service or Alberta Disaster Services.

> The justification of various forms of relief is that they ease the immediate distress and aid initial rehabilitation. It is sometimes a very useful adjustment to floods. Generally, however, it tends to become regarded as a right rather than a charitable gift. As a consequence, it tends to remove the incentive to avoid future flood losses, and therefore encourages persistant occupance of the flood plain.
>
> (Sewell 1969, p.65)

In 1969, Sewell also noted that persistent human occupance of flood plain areas is closely tied to the granting of public relief, particularly when there is no obligation on the part of the recipient to reduce his susceptibility to future flood losses. As a result of this type of observation, under the United States National Insurance Act, federal

relief payments in known hazard areas are not awarded unless affected individuals have purchased flood insurance (Burton et al. 1978, p.65). Similarly, under the Canadian Flood Damage Reduction Program, federal flood disaster aid for new development is to be discontinued once a flood risk area has been identified and publicized (Bruce et al. 1977, p.61).

c) Tax Adjustments

Several authors have suggested that tax adjustments can be useful to discourage flood plain development (Phippen 1970; Goddard 1976). Goddard (p.89) noted that they have rarely been used because of "lack of understanding and support, intricacies of application and adverse public attitude". An additional reason could be that property tax rates are set by the municipality, and generally, flood damage reduction programs are administered at the provincial or national level. However, as municipal authorities begin to plan for flooding, additional property tax revenue collected from flood plain occupants would help to relieve the associated costs that are not paid by the provincial or federal governments.

Tax adjustments could be used to encourage landowners to forfeit the right to use the land or to use it in a manner consistent with a designated plan. Types of adjustments include: tax assessment on the basis of current rather than potential use, deferred tax payments prior to public purchase and reduced tax assessment if the landowner forfeits certain rights (Goddard 1976, p.89).

Flood plain occupants may promote writing off taxes if a property is subject to flooding because property values are lower, as was

reported for parts of the Grand River basin by Mitchell and others (1978, pp. 102-4). If property taxes are based on the market value, as is the case in Alberta, flood plain property taxes should be lower than non-flood plain property taxes, if flood plain property values are lower. However, lower taxes could encourage, rather than discourage, flood plain occupance, especially if the reduced tax rate is perceived to outweigh anticipated flood losses.

Increased taxes for flood plain development could be applied to offset the costs of flood plain occupance to society and to discourage new development of the flood plain. Since property taxes are the single municipal government revenue source, the municipality may favor increased revenue from flood plain property, but may be reluctant to discourage new development and associated tax revenue through high taxes.

d) Public Land Purchase

Public land purchase places the cost of alleviating flood damages on society as a whole. Although future relief and rehabilitation costs are removed, society must bear the cost of purchasing the land and converting it to another use. Like the other adjustments which spread the loss to society, this adjustment reduces potential flood damage. Moreover, it has the added benefit that society may gain from using the public land for recreation purposes, if the flood plain is converted to parkland.

The main consideration in flood plain purchase is cost (Ingram 1976, p.48). If an area is highly developed, the costs, both monetary and in terms of public opposition, would be prohibitive. However, if an area is sparsely populated, public purchase may be the best answer. Public

land purchase can serve the dual purposes of directing development away from the flood plain and providing open space for recreation, for example the Metropolitan Toronto Region Conservation Authority ravine purchases following Hurricane Hazel in 1954 (Giles 1976, p.16).

Public land purchase is most successful following a large flood, when government agencies are prepared to purchase flood plain land and when flood plain occupants are willing to move away from the flood plain. Mitchell and others (1978, pp. 104-5) reported that flood plain properties were vacated and sold to the government following the 1974 Grand River flood. However, in the Grand River basin "government land acquisition is not an important part of an overall flood management strategy and ...has occurred sporadically as funds and properties have become available".

e) Private Insurance

Insurance companies, as a rule, will not offer flood insurance to flood plain occupants. "Early experience with offering flood insurance in the United States led the insurance industry to maintain that private flood insurance is an impossible coverage on the basis of normal insurance procedures" (Vaughan 1971, p.12). A similar stance is held by their Canadian counterparts. The reason for this is clear: only those people who are susceptible to flooding would purchase flood insurance. In 1971, Vaughan estimated that less than ten percent of dwellings in the United States were exposed to any flood hazard,[4] and as few as two

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[4] By comparison, in 1965, Sewell estimated that approximately twelve percent of the Canadian population lived in areas subject to periodic inundation.

percent of these could be expected to suffer more than half of the total average annual flood damage. This high concentration of losses would require companies to build extensive reserves, which are likely to be taxed as excess reserves (Vaughan 1971, p.12) and which could be depleted following a single event.

In Ontario, Mitchell and others interviewed residents and municipal officials in the Grand River Basin and found that flood insurance was not available at any cost. An interview with a representative of a large insurance company revealed that "underwriting floods was a risky business and insurance companies were not in business to take large risks". Mitchell concluded that although flood insurance can be acquired in certain circumstances, insurance companies do not provide flood insurance if the property has a history of flooding or flood-related damages. Thus, at the present time in Canada, "the people who can get flood insurance are the people who probably don't need it" (Mitchell et al. 1978, p.105).

f) Reschedule Production

In an area that frequently experiences flooding at a particular time of year, managers of industrial or commercial establishments can schedule production accordingly. For example, they can plan operations to ensure that inventories are low when spring flooding may be expected. To be most effective, managers should adopt flood proofing and should have access to flood forecasting information.

g) Individual Bear the Loss

If it were not for the social conscience of the government, local authorities and various relief organizations, individual flood plain occupants would be forced to bear the entire burden of costs attributable to flooding, as well as enjoy the benefits associated with the flood plain location. In most developed countries, the majority of the cost is transferred to society as a whole, through publicly constructed flood control projects, publicly financed flood forecasting, publicly sponsored relief funds, and so forth. However, property owners generally pay the costs such as loss of property, income and loss of life. Because of the high costs being paid by the United States government for flood relief, recent policy is transferring more of the financial responsibility for flood plain occupation to the occupant through cost-sharing programs, flood proofing and flood insurance. In some respects, Canada is following the American example.

3.3 Choice of Adjustment

Although people coping with environmental risk and uncertainty appear to take into account likely economic outcomes, "behaviour rarely conforms to what should be optimum by their standards of utility" (Burton et al. 1978, p.85). Kates (1962) showed that the choice of adjustment to a hazard is based on the manager's perception of the hazard, his awareness of possible adjustments, and his evaluation of these adjustments in terms of their suitability for the environmental setting, technical feasibility, economic efficiency and conformance with social guides.

Based on past natural hazard and other research, Burton and others (1978, pp.87-90) outlined the process of choice of hazard adjustments.

The appraisal of extreme events and consideration of alternatives are independent; most people have difficulty evaluating more than one alternative at a time. People deal with alternatives in an ordered sequence, rather than simultaneously, in three stages. Initially, a threshold of awareness of actual or anticipated loss is reached. This limit will vary greatly among different people. When the first limit is exceeded, the person thinks about the event and ways of dealing with it. The second threshold is crossed when a person suffers damage from the event and must adopt a purposeful action to modify or remedy the loss. The third threshold is crossed when the person feels compelled to relocate his activities. It is suggested that the choice process is "ordered choice" which assumes that people can compare only a relatively small number of alternatives and that they apply evaluation criteria in a rough order of importance related to the problem at hand.

3.3.1 Perception of the Hazard

Persons with greater experience with floods generally perceive and adopt more adjustments than those with little experience (Kates 1962; Burton 1962). However, future expectation of the hazard is not always related to the individual's past experience. Saarinen (1974) stated that many people are ill-at-ease with the uncertainty of natural hazards, thus, they will eliminate the hazard by denying its existance or recurrance or transferring responsibility for uncertainty to a higher power (Figure 3.4).

Burton and Kates (1964) suggested that hazard perception is related to the frequency of the hazard. That is, the more frequently the

Figure 3.4

HAZARD PERCEPTION

Eliminate the Hazard		Eliminate the Uncertainty	
DENY OR DENIGRATE ITS EXISTENCE	DENY OR DENIGRATE ITS RECURRENCE	MAKING IT DETERMINATE AND KNOWABLE	TRANSFER UNCERTAINTY TO A HIGHER POWER
"We have no floods here, only high water."	"Lightening never strikes twice in the same place."	"Seven years of great plenty... After them, seven years of famine."	"It's in the hands of God."
"It can't happen here."	"It's a freak of nature."	"Floods come every five years."	"The government is taking care of it."

Source: Burton, Kates and White 1968, p.18.

hazard occurs, the greater the awareness and the broader the range of adjustments considered.

There is considerable evidence that perception of the hazard is a function of resource use. Farmers and others working closely with the environment are particularly sensitive to environmental threats, such as flooding, whereas urban residents, industrialists and manufacturers perceive the hazard less readily (Mitchell 1974, p.330).

Burton and others stated that the time horizon of the flood plain occupant affects his use of the flood plain (1978, p.96). For example, a developer, who will sell his property as soon as it is developed, will perceive very little or no hazard, but the planner, basing his recommendations on past flood events will be more inclined to perceive a hazard.

Thus, if the flood plain occupant does not perceive that he is located in a flood-prone area, he will not be likely to be aware of or adopt means to overcome the flood hazard. Perception of the hazard appears to be related to past experience, event frequency, perceived protection, resource use and the time horizon of the flood plain occupant or manager.

3.3.2 Awareness of Adjustments

For any hazard, a large number of adjustments are theoretically possible, as outlined above for the flood hazard. In practice, only a few are known to the individual manager; the result may be that the adjustment is much less effective than it could be if the whole range was considered (Sewell 1969, p.440). Factors broadly influencing resource managers' awareness of adjustments include socio-economic status

and role responsibility, past experience, hazard frequency and the environmental, technical, economic and social constraints. Many studies suggest that socio-economic variables (such as age, education and socio-economic status) exert less influence on adoption decisions (Burton et al. 1968, p.19).

Thus, even if a flood plain occupant perceives that he lives in a flood-prone area, he may only be aware of a small number of adjustments that he may undertake to reduce potential damages. Even if he is aware of a number of alternatives, the number adopted is usually small.

3.3.3 Adoption of Adjustments

When adopting adjustments, people tend to minimize expected losses, but the relative value they place on loss of time, property and income differs according to personality traits and cultural, economic and social constraints, including the role played by the government (Burton et al. 1978, p.105). Burton and others (1978, p.106-7) identified four classes of factors which seem to be associated with the decision to adopt an adjustment. First, prior experience with the hazard is often related to the type and number of adjustments selected. Second, the material wealth of individuals is generally associated with the extent to which they take risks or are able to adopt adjustments. Third, personality traits may affect the way a person reacts, particularly in the face of a disaster. Fourth, the perceived role of the individual in a social group may affect his decision.

Thus, adoption of adjustments to flooding is closely related to the flood plain occupant's perception of the hazard and awareness of alternative adjustments. This explains why, in many instances, adoption

of measures to alleviate flood damages are undertaken immediately following a flood, when perception of the hazard is greatest. Resource managers tend to rely on a small number of adjustments because they are aware of them and may have had past experience with them.

Public education about the degree of risk, about the range of adjustments and about implementation methods could play an important role to acquaint flood plain dwellers with the hazard and with the broad range of possible adjustments available.

3.4 Discussion

Flooding is a natural phenomenon of all rivers. Flooding becomes a natural hazard when man's use of the land is damaged or endangered by flood waters. Throughout the world, most cities and towns are located in river valleys both for functional and aesthetic reasons. However, as populations expand onto the flood plain, potential and actual flood damages increase. In Canada and the United States, federal, provincial/state governments have undertaken construction schemes to protect flood plain occupants. However, in spite of these efforts, flood damages continued to escalate. Thus, the Canadian government adopted a National Flood Damage Reduction Program and the United States government adopted a Unified National Program for Reducing Flood Losses to consider a broader range of flood damage adjustments.[5]

The range of possible adjustments to the flood hazard was discussed

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[5] The National Flood Damage Reduction Program and Alberta's commitment to federal-provincial cost-sharing programs is discussed in chapter four (sections 4.3.3 and 4.3.4) and chapter five (section 5.2).

using the natural hazards model developed by Burton and others (1968). However, other authors have organized the range of adjustments using different models. For example, Kates (1962) used White's theoretical range of choice as a starting point and identified individual actions presently available and suggested ways that municipal, state and federal authorities could encourage, reinforce or provide a mandate for individual action" (1962, p.5). The Tennessee Valley Authority developed a framework which divided flood damage reduction into preventive measures, such as flood plain use regulation, tax adjustments and flood insurance and corrective measures, such as flood control, evacuation, forecasting and so forth (Figure 3.5). Phippen of the U.S. Army Corps of Engineers used the same basic framework as Burton and others (1968) to suggest fifteen possible adjustments to the flood hazard under the headings: modification of flooding, modification of use susceptibility and modification of impact on individuals (Figure 3.6).

Since White's 1961 study of the range of choice of adjustments to the flood hazard, the range has increased considerably. White identified six adjustments in the range of choice; in 1978, Mitchell and others included eighteen separate adjustments (Figure 3.7)[6] Since 1961, all researchers have considered that flood control, flood proofing, emergency action, and flood insurance are theoretically possible. Emergency action followed by flood control were the traditional methods of flood damage reduction available to governments when the flood hazard

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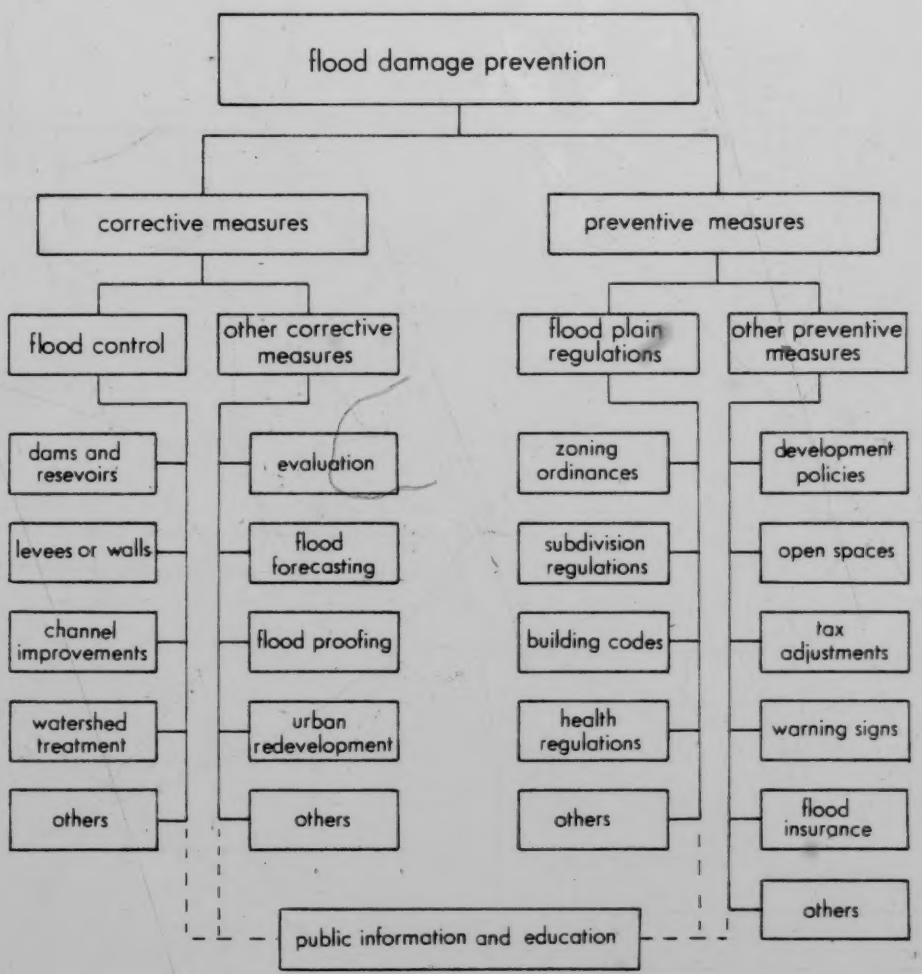
[6]Three of these are not indicated on the chart because they have been included with other adjustments by previous authors: stream diversions, subsidized relocation and relief funds.

Figure 3.5

THE TENNESSEE VALLEY AUTHORITY FRAMEWORK FOR FLOOD DAMAGE PREVENTION



Source: I.Burton and R.Kates. 1964. p.369.

Figure 3.6

FLOOD PLAIN MANAGEMENT OPTIONS

MODIFICATION OF FLOODING

Flood storage
  Uncontrolled release
  Controlled release

Channel improvement

Dykes, walls and levees

Diversions

Land Treatment

Weather modification

MODIFICATION OF IMPACT ON INDIVIDUALS

Flood insurance

Public relief

Tax write-offs

MODIFICATION OF USE SUSCEPTIBILITY

Land use regulations (horizontal)
  "Floodway"
  Zoning
  Subdivision regulations

Land use regulations (verticial)
  Flood proofing with (or without):
    Zoning
    Subdivision regulations
    Building and related codes

Development policies
  Direction of services and utilities
  Public use acquisition and easement
  Redevelopment
  Permanent evacuation

Forecasting and warning systems
  Emergency closures and removals
  Flood fighting

Public information and education

Source: Phippen 1970, pp. 642-3.

Figure 3.7

THEORETICAL RANGE OF ADJUSTMENTS TO THE FLOOD HAZARD: SELECTED AUTHORS

	White (1961)	Kates (1962)	Tennessee Valley Authority (1962)	White (1964)	Burton and Kates (1964)	Corps of Engineers (1967)	Burton, Kates and White (1968)	Sewell (1969)	Phippen (1970)	Jevdjevich (1974)	Saarinen (1974)	James (1975)	White (1975)	Mitchell et al. (1978)
Modify the Cause														
watershed management	•		•	•		•	••		••	••	••		•	••
weather modification							••		••	••	••			••
Modify the Hazard														
flood control	•	•	•	•	•	•	•	•	•	•	•		•	•
Modify the Loss Potential														
flood forecasting			•			•	•		•	•	•		•	•
flood proofing and building codes	••	••	•	••	••	••	••	••	••	••	••	••	••	••
emergency action		•••	•••	•••	•••	•••	•••	•••	•••	•••	•••	•••	•••	•••
land use management			•					•	••	•				••
permanent evacuation			••					••	••					••
development policies									•					
warning signs					•			••			•			•
public education									•					•
Adjust to the Loss														
Spread the Loss														
subsidized insurance	••	•	•	••	••	•	••	•	•	•	•	•	•	•
public relief			•	•		••	••	•••	••	••	••	•••	•••	•••
tax adjustments								•						
public land purchase								•						•
Plan for the Loss														
private insurance	•	•	•	•	••	•	•	•	•	•	•	•	•	•
reschedule production								•						
Bear the Loss	•	•		•	•	•	•			•				•

research commenced. However, since that time, flood proofing and insurance have become part of the United States government flood management policy and flood proofing is being studied in Canada (James F. MacLaren Limited 1978). Kates (1962) added land use management to the theoretical range of choice. This adjustment is being implemented in United States communities through the incentives of the flood insurance program. The Canadian Flood Damage Reduction Program is also trying to provide incentives for community planning of flood plain land uses. Flood warning systems have been implemented in both the United States and Canada. Other adjustments, such as municipal development policies, public land purchase, tax adjustments are the responsibility of local governments and have been implemented in varying degrees in Canada and the United States. Financial incentives can be used by the central government to promote these types of adjustments.

Thus, no single adjustment will, in itself, significantly reduce flood damages. Rather, adjustments should be considered in combination. As research in the area of flood damage reduction continues, it often tends to become specific and focus on a particular adjustment. However, many researchers realize that a combination of adjustments, both structural and nonstructural, is frequently warranted. For example, Day and Lee (1976) concluded that the benefits of a flood warning system are related to the degree of flood plain development, flood proofing and community preparedness; and James F. MacLaren Limited found that flood proofing benefits cannot be properly evaluated without considering land use policies, flood plain development, public education, warning systems and flood insurance. Although White (1975) pointed out that these interrelationships have not been documented, there is sufficient

evidence to indicate that no single adjustment can be considered, in itself, as a solution to the flood problem. It is imperative to consider a combination of adjustments to reduce potential flood damages.

In the following chapter, the existing adjustments to the flood hazard in the Drumheller Valley are described. Adjustments used in the past and those not yet considered are outlined. Flood plain land use management policies are discussed in chapters five, six and seven.

CHAPTER IV

ADJUSTMENTS TO THE FLOOD HAZARD IN THE DRUMHELLER VALLEY

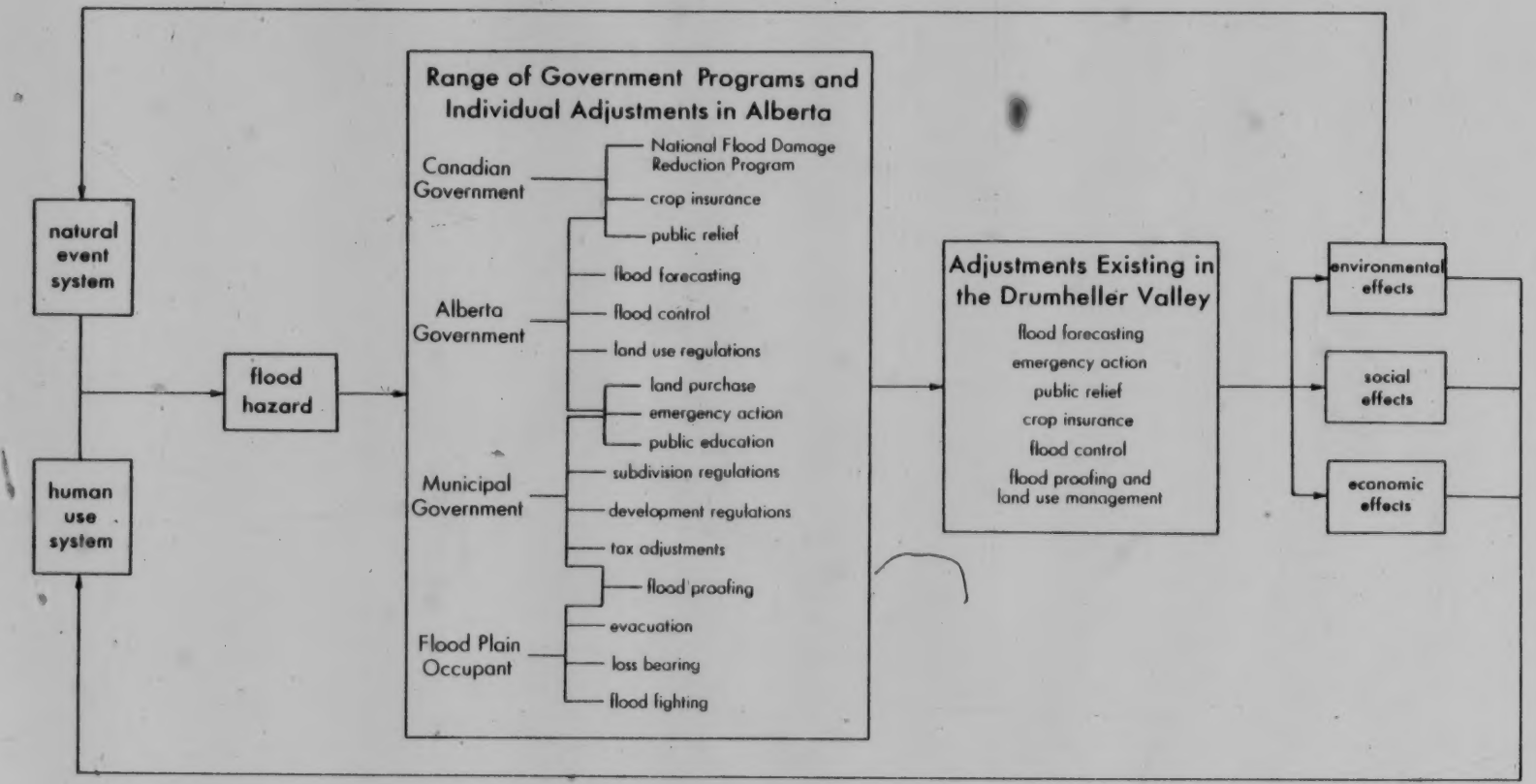
4.1 Introduction

The Red Deer River and tributary creeks have flooded in the Drumheller Valley at least fourteen times since the valley was settled in the early 1900s. Despite the fact that overbank flood damages have not been experienced since 1954, certain programs are available to reduce the flood damage potential.

The existing range of choice of adjustments to the flood hazard in Alberta is outlined in Figure 4.1, within the systems framework developed by the natural hazards researchers, which recognizes that the flood hazard results from the interaction of the human and physical systems (White and Haas 1975, p.201). In Alberta, adjustments may be undertaken by the federal, provincial and municipal governments or by the flood plain occupant. The Canadian and Alberta governments share the costs of two programs to reduce the cost burden of flood damages: crop insurance and disaster assistance programs, which provide public relief in the event of a flood. The Canadian and Alberta governments are presently negotiating an agreement under the National Flood Damage Reduction Program, discussed in chapter five. The Alberta government offers flood forecasting services and may construct structures to control flood flows or may directly regulate land uses in flood control areas. In conjunction with the municipalities, the provincial government may purchase flood plain land or offer a public education program to alert flood plain residents of the flood hazard and of mitigation

Figure 4.1

SYSTEM OF FLOOD HAZARD ADJUSTMENTS: THE DRUMHELLER VALLEY



measures. Most communities in Alberta have an emergency preparedness program to prepare for emergencies, including flooding. Municipalities may directly control flood plain land uses through subdivision and development regulations. Tax adjustments may be used by the municipalities to direct flood plain development patterns, although they have not been so used in Alberta. Flood proofing of new or existing development may be required by the municipalities; flood proofing costs are borne by the individual flood plain occupant. Finally, the costs of evacuation, flood fighting and loss bearing may be borne by the individual flood plain occupant.

In the Drumheller Valley, these available adjustments are combined in six general adjustment programs which are used, or will be used in the future: flood forecasting, emergency action, public relief, flood control and flood proofing and land use management. The environmental, social and economic effects of each of these adjustments and the feedback into the natural and human systems are not discussed. However, these effects are examined for the alternative land use policies which are discussed in chapters six and seven.

In this chapter, the history of flooding in the Drumheller Valley is described and existing flood hazard adjustments are outlined. In the conclusion, the adjustments used in the past, existing and under study are compared to the theoretical range of choice of adjustments outlined in chapter three.

4.2 The History of Flooding

4.2.1 Hydrologic Record

Red Deer River streamflow has been recorded at the Drumheller bridge

from 1915 to 1931 and from 1959 to the present. There is no record for the intervening 28 years. Between 1924 and 1931, the gauge was operated seasonally. There is a limited seasonal record for Kneehill Creek (1921 to 1936, 1957 to the present) and the Rosebud River (1922 to 1936, 1951 to the present). Michichi and Willow Creeks are ungauged. A more complete record is available for the City of Red Deer, 180 km upstream of Drumheller, where Red Deer River streamflow has been recorded continuously from 1912 until the present, with the exception of two years between 1933 and 1935.

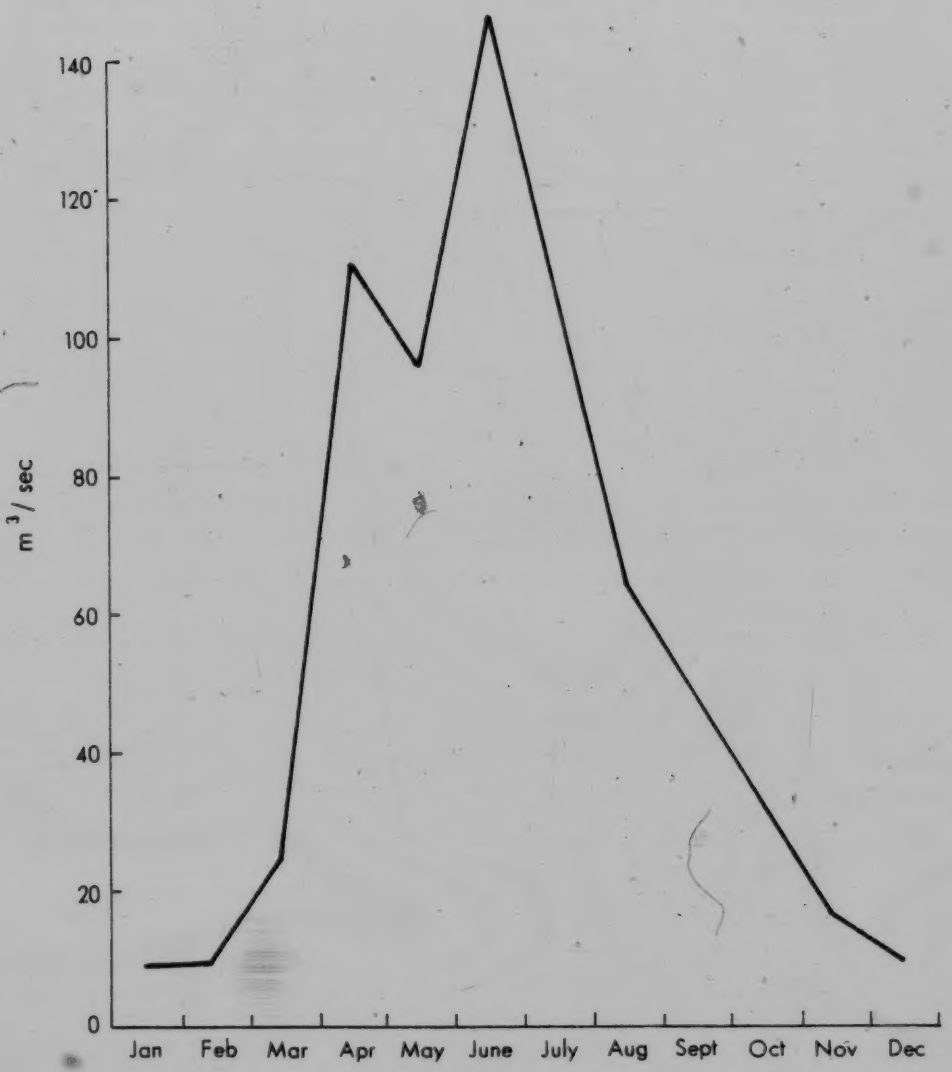
Red Deer River streamflow is not controlled. The hydrograph of mean monthly flow for the Red Deer River at Drumheller has two peaks (Figure 4.2). High mean monthly flows generally occur in April and result from plains snowmelt combined with rainfall or icejamming. High mean monthly flows also occur in June and result from heavy rains in the foothills of the Rocky Mountains, which may be augmented by mountain snowmelt.

Bankfull discharge at the Drumheller gauge is estimated to be 1,019 cubic meters per second (m^3/sec), and to have a return period of 10.5 years (Alberta Research Council 1972, p.12). Streamflows exceeding this volume were recorded in 1920 (1,121 m^3/sec) and 1923 (1,132 m^3/sec) (Table 4.1). The Alberta Department of the Environment, River Engineering Branch (1975, p.7) noted that overbank flow and flooding also occurred in 1915 (estimated 2,024 m^3/sec), 1952 (estimated 1,274 m^3/sec) and 1954 (estimated 1,444 m^3/sec).

The 1:100 year flood of the Red Deer River at Drumheller is calculated to have a mean daily discharge of 1,869 m^3/sec and a maximum instantaneous discharge of 2,157 m^3/sec (Alberta, Department of Environ-

Figure 4.2

RED DEER RIVER AT DRUMHELLER: MEAN MONTHLY DISCHARGE (1916 TO 1931, 1959 TO 1976)



Source: Canada. Department of Fisheries and Environment. 1977. p.262

Table 4.1

CORRESPONDING FLOODS AT THE CITY OF RED DEER AND THE CITY OF DRUMHELLER

Year	Date of Peak Flow	Flow at Red Deer (m^3/sec)	Flow at Drumheller (m^3/sec)	Source
1915	June 20	-	-	Alberta Department of Environment 1974.
	June 27	1,586	-	Canada Department of Fisheries and Environment 1977.
	June 27	-	2,024	Alberta Department of Environment 1975.
1920	March 9	716	1,121	Canada Department of Fisheries and Environment 1977.
1923	June 2	985	1,131	Canada Department of Fisheries and Environment 1977.
1952	April 7-10	-	-	Edmonton Journal, Calgary Herald.
	April 28	-	-	Alberta Department of Environment 1974.
	June 24	1,073	-	Canada Department of Fisheries and Environment 1977.
	June 24	-	1,274	Alberta Department of Environment 1975.
1954	August 26	1,206	-	Canada Department of Fisheries and Environment 1977.
	August 26	-	1,444	Alberta Department of Environment 1975.
	August 28	-	-	Alberta Department of Environment 1974.

ment, Planning Division 1979). The maximum daily discharge experienced, but not recorded, at Drumheller is estimated to have been greater than the 1:100 year flow, at 2,024 m^3/sec on June 27, 1915 (Alberta Department of Environment, River Engineering Branch 1975, p.7).

4.2.2 Past Floods

The following discussion of past floods in the Drumheller Valley is based on three information sources. First, the Red Deer River streamflow record was used to identify flows exceeding 1,019 m^3/sec, which is bankfull discharge at the Drumheller bridge. This volume was exceeded on March 9, 1929 and June 2, 1923 (Canada, Department of Fisheries and Environment 1977, p.262). Second, two reports prepared by the Alberta Department of the Environment, River Engineering Branch (1974, 1975) estimated the 1915, 1952 and 1954 discharges, based on high water marks, interviews with local residents and the City of Red Deer streamflow record.[1] Third, newspaper accounts of Red Deer River floods, contained in a file compiled by the Alberta Department of the Environment, Technical Services Division, provided information about flood damages and flooding of ungauged tributary streams.

Seven of the fourteen Drumheller Valley floods occurred in March or April, and resulted from local snowmelt combined with rainfall or ice jams (Table 4.2). The remainder occurred between May and August, and

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[1] Using various sources, the dates for floods at Red Deer and Drumheller are compared in Table 4.1. Estimates are not available for the time required for the flood crest to travel from Red Deer to Drumheller. Thus, there are discrepancies among the dates provided by the Alberta Department of the Environment, the Canada water survey records and newspaper records.

Table 4.2

DRUMHELLER VALLEY FLOODS

Year	Date	Discharge (m^3/sec)	Cause	Effects	Emergency Action	Source
1901				-larger than 1915 flood		Alberta Department of Environment 1974.
1915	June 20	Red Deer River				Alberta Department of Environment 1974.
	June 27	2,024, Red Deer River	rainfall	-severe flooding in Midlandvale, Newcastle -minor flooding in Nacmine, Drumheller, Rosedale, Cambria		Alberta Department of Environment 1975.
	June 28			-peak flood occurred		Whyte 1917.
1920	Apr. 19	Rosebud Creek		-two bridges on Rosebud Creek washed out		Calgary Herald, Apr. 19 and 29, 1920.
	May 10	1,121, Red Deer River	local rainfall	- no damaging floods		Canada Department of Fisheries and Environment 1977.
1923	June 2	Red Deer River	rainfall	-no damaging floods -six feet below danger level		Calgary Herald, June 2, 1920.

Table 4.2-Continued

Year	Date	Discharge (m^3/sec)	Cause	Effects	Emergency Action	Source
1923 (cont)	June 3	1,131, Red Deer River				Canada Department of Fisheries and Environment 1977.
1930	Apr. 15	Rosebud Creek	"cloudburst"	-three lives lost		Lethbridge Herald, April 15, 1940.
1940	Apr. 7	Red Deer River	"ice-jam"	-water was four feet deep in Newcastle -1,000 people were homeless in the Drumheller Valley and Carbon		Red Deer Advocate, April 7, 1940.
	Apr. 15	Red Deer	"ice-jam" east of East Coulee	-100 families were evacuated in East Coulee, Wayne, Rosedale -100 families were evacuated in Newcastle		Lethbridge Herald, April 15, 1940.
		Rosebud Creek	"thaw" and release of irrigation dam	-50 houses under water		Lethbridge Herald, April 15, 1940.

Table 4.2-Continued

Year	Date	Discharge (m^3/sec)	Cause	Effects	Emergency Action	Source
1943	Apr. 6	Red Deer River	"ice-jam"	-homes were flooded in Nacmine, Midlandvale, Rosedale and a portion of River Drive in Drumheller	-assistance was provided by the reserve army	Lethbridge Herald, April 6, 1943.
1947	Mar. 22	Red Deer River	"ice-jam"	-homes were evacuated in Newcastle, North Drumheller, Rosedale		Calgary Herald, March 22, 1947.
1948	Apr. 23 to 28	Red Deer River, Rosebud Creek, Michichi Creek	"ice-jam" local snow melt		-emergency broadcasts by Calgary radio stations	Calgary Herald, April 23, 1948.
				-2,000 people were evacuated in Wayne, Midlandvale, East Coulee, Star Mine, Drumheller	-assistance was provided by the RCMP and Calgary Red Cross	Calgary Herald, April 24, 1948.
				-170 homes were flooded in East Coulee -48 of 50 homes were flooded in Lehigh	-RCMP boat patrol to prevent looting	Calgary Herald, April 26, 1948.

Table 4.2-Continued

Year	Date	Discharge (m^3/sec)	Cause	Effects	Emergency Action	Source
1948 (cont)					-Rotary Club and Red Cross registered flood victims -a Disaster Relief Committee was chaired by G. Taylor, MLA.	Calgary Herald, April 26, 1948.
				-100 families were evacuated in North Drumheller	-Drumheller Valley Disaster Relief Committee collected $1,300.00 -Calgary branch of the Canadian Legion collected $600.00 -Elks Hall was used for flood victims -Salvation Army distributed blankets and mattresses -Red Cross and Salvation Army collected food and clothes	Calgary Herald, April 28, 1948.
1951	Apr. 5 to 7	Michichi Creek		-300 people were evacuated from 100 homes in North Drumheller		Calgary Herald, April 7, 1951.

Table 4.2-Continued

Year	Date	Discharge (m^3/sec)	Cause	Effects	Emergency Action	Source
1951 (cont)					-Drumheller Civil Defense warned people of floods	Calgary Herald, April 5, 1951.
					-Drumheller Community Chest collected donations	Calgary Herald, April 9, 1951.
1952	Apr. 7	Red Deer River, Michichi Creek	rainfall/ snowmelt	-20 homes were evacuated in Newcastle	-RCMP, Drumheller Civil Defense worked to ensure people were not trapped	Edmonton Journal, April 7, 1952
				-70 families were evacuated in Newcastle and North Drumheller		Calgary Herald, April 7, 1952.
	Apr. 28	Red Deer River				Alberta Department of Environment 1974.
	June 24	1,274, Red Deer River				Alberta Department of Environment 1975.
	June 25	Red Deer River	rainfall	-flood peaked -25 homes were evacuated in Newcastle and North Drumheller		Calgary Herald, June 26, 1952.

Table 4.2-Continued

Year	Date	Discharge (m^3/sec)	Cause	Effects	Emergency Action	Source
1954	Aug. 26	1,444, Red Deer River	rainfall			Alberta Department of Environment 1975.
	Aug. 28	Red Deer River				Alberta Department of Environment 1974.
	Sept. 1	Red Deer River		-many families were evacuated in Drumheller		Red Deer Advocate, September 1, 1954.
1965	Apr. 7	Rosebud River	"ice-jam"	-7 homes were evacuated in Rosedale	-assistance was provided by the Drumheller Civil Defense	Calgary Herald, April 7, 1965.

resulted from local precipitation or rainfall in the foothills of the Rocky Mountains.

Eight of the fourteen floods were caused by Red Deer River flooding as a result of heavy spring or summer rainfall or local snowmelt which may have been augmented by mountain snowmelt in summer months. Four were caused by simultaneous flooding of the Red Deer River and tributary creeks during spring snowmelt. One was caused by flooding of Rosebud Creek during a summer rainstorm, and one was caused by Michichi Creek flooding during the spring thaw. Most floods occurred when the rivers were not gauged, thus, there are some discrepancies among the various reports of timing and magnitude.

4.3 Existing Flood Hazard Adjustments

There are certain measures available to cope with a flood in the Drumheller Valley, despite the fact that only one minor flood has been experienced since 1954, and no overbank flow of the Red Deer River has occurred since gauging commenced again in 1959. Existing adjustments have been introduced by the Alberta government as part of province-wide programs. Additional means to reduce the flood damage potential are being evaluated in the Drumheller Flood Control Study. The provincial government, not the municipal authorities, has been the initiator of these programs.

4.3.1 Flood Forecasting

The Alberta Department of the Environment, Flow Forecasting Branch monitors rainfall and runoff in all populated river basins of Alberta, including the Red Deer River basin, and provides flow forecasts for flood

warnings. If flooding and community disruption are anticipated, Alberta Environment is responsible for alerting the municipal authorities who will initiate a prepared plan. Since there have been no Drumheller Valley floods since this program has been in operation, its effectiveness has not been tested in the Valley. Moreover, the Department of the Environment may not have reliable estimates of the time for the flood crest to pass down the Red Deer River. According to newspaper accounts of historical flood events, there is at least a 24-hour lag time between the City of Red Deer and City of Drumheller flood peaks. However, according to the 1975 River Engineering Branch report, the 1915, 1952 and 1954 floods occurred on the same day in both cities. This is unlikely. More precise information is needed for effective flood forecasting in the Red Deer River Basin.

4.3.2 Emergency Action

Under the Disaster Services Act (1973), each Alberta municipality must have a disaster preparedness program. Alberta Disaster Services, a department of the Alberta public service, offers "assistance and guidance to Alberta government departments and municipalities in developing programs of preparedness for, and response to, emergencies and disasters" (Alberta Disaster Services 1977, p.9).

The City of Drumheller has a Peacetime Emergency Operations Plan (1978), which may be implemented during a flood event. The mayor has the power to declare a disaster, to mobilize groups such as firemen, police and volunteers and to order evacuation of designated areas. Sand and sandbags are available for emergency dyking. In the case of a severe emergency, the Lieutenant Governor in Council may declare an emergency

for all or part of Alberta and mobilize a prepared plan. Researchers have found that the effectiveness of warning and emergency action programs in reducing flood damages is reliant on public preparation and awareness (Day and Lee 1976; Sniedovich and Davis 1977). The potential effectiveness of the Drumheller emergency plan in coping with flooding is not known because the Drumheller Valley has not experienced flooding since this program came into existance.

4.3.3 Public Relief

Alberta Disaster Services provides for government financial assistance to any areas of the province experiencing an emergency, including flooding. Compensation rate is determined by government policy. Presently, it is: 80% of the appraised value for residences and contents and 100% for municipal properties and operations. Compensation to businesses is assessed separately. The Canada Department of Finance, under the Disaster Assistance Program, may reimburse the province using the following cost-sharing formula: where the province's expenditures exceed $1.00 per capita, 50% of the next $2.00 is eligible for cost sharint, 75% of the next $2.00 per capita, and 90% of the remainder are eligible for cost sharing (Canada, Department of Fisheries and Environment 1976, p.83; Hennie 1977, p.70).

The Disaster Services program does not discourage development of flood-prone land. Funding is provided to flood victims to rebuild in the same location, rather than to move out of the flood-prone area.

4.3.4 Crop Insurance

Alberta farmers may purchase crop insurance for all crops, with the exception of hay, on flood-prone land under the All-Risk Crop Insurance program administered by the Alberta Hail and Crop Corporation, a crown corporation created by the Alberta Hail and Crop Insurance Act (1969). Crop insurance covers the loss of production caused by unavoidable natural events, including flooding and drought. The Canada Department of Agriculture subsidizes the program by paying one-half of each farmer's premium. The Alberta government pays for program administration (Alberta Hail and Crop 1976; Hoffman 1977, p.69-70). Average insurance premiums were $2.00 to $3.00 per acre in 1977, but without government subsidy, they would have been $10.00 to $12.00 per acre (Rains 1977). Actual coverage varies from $20.00 to $70.00 per acre, depending upon the crop, soil type and potential yield (Hergert 1977). In the spring of 1977, over one million dollars was paid to 750 claimants throughout Alberta for flood-related losses (Rains 1977).

Six farmers insured farmland in I.D. No. 7 in 1979.[2] The Alberta Hail and Crop Corporation has not paid a crop claim, as a result of flooding, since it has been in existance (Rains 1979). However, this program encourages agricultural use of flood plain land in Alberta. Since crop insurance rates are not calculated to take flood frequency into account, most of the risk is shared by the provincial and federal governments.

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[2] The policy of the Alberta Hail and Crop Corporation does not allow employees to divulge information about individual properties. Thus, it is not known whether these properties are on the Drumheller Valley flood plain.

4.3.5 Red Deer River Flow Regulation

Presently, Red Deer River streamflow is uncontrolled. But, on July 18, 1977, the Alberta government announced that it would construct a storage reservoir on the Red Deer River between Red Deer and Sundre at a location known as "site 6" (Quinn 1977, p.128). This followed almost ten years of study by the Alberta Department of the Environment and two sets of public hearings held by the Environment Conservation Authority, which is now known as the Environment Council of Alberta (ECA). The dam is intended to help manage the Red Deer River to achieve the following objectives: maintenance of a seasonally adequate water supply, enhancement of water quality and reduction of damages from flooding and erosion (Alberta, Department of Environment, Planning Division 1976a, p.4).

The Red Deer Dam will not eliminate Drumheller Valley flood damages. It has been estimated that under optimum operating conditions, it may reduce the 1:100 year flood damages by about forty percent (Klohn Leonoff Consultants Limited 1976, p.24; Klohn Leonoff Consultants Limited 1977, p.4). Thus, the Alberta Department of the Environment, Planning Division is studying flood protection in more detail as part of the Drumheller Flood Control Study.

a) Events Leading to Adoption of the Red Deer Dam

In the mid-1960s, a "Red Deer River Basin Development Plan" was proposed by the Alberta government as part of the Prairie Rivers Improvement and Management Evaluation Program (PRIME). This plan involved a series of on-stream and off-stream reservoirs to divert water to East Central Alberta for irrigation.

(Alberta, Department of Agriculture, Economics Division 1968). This project did not materialize, and in 1970, a study was conducted to examine the feasibility of constructing a dam on the Red Deer River near Raven, as part of a system to divert water from the North Saskatchewan River near Rocky Mountain House to the Bow River east of Calgary for irrigation. With the growing unpopularity of interbasin water diversion projects and the lack of enthusiasm on the part of the farmers, this proposal was not developed. In 1971, in a study of "Red Deer Flow Regulation", twenty possible dam sites on the Red Deer River were examined, including the former Raven dam site, which was renamed "site 7" (Bailey 1971). Impetus to construct a dam on the Red Deer River was provided in 1972, when the Alberta government announced a policy of equalizing opportunities for industrial development throughout the province. Since Red Deer River streamflow is highly variable, it was felt that streamflow must be regulated to provide a guaranteed seasonal water supply which would attract industrial development to the Red Deer area (Alberta Environment, Planning Division 1975a, p.2).

On October 30, 1973, the Minister of the Environment announced the terms of reference for the Red Deer River Flow Regulation Planning Study. It was assumed that by using a single means, a multiple purpose reservoir, existing river basin problems, including inadequate winter water supply, deteriorating water quality, flooding and erosion would be alleviated. In addition, the reservoir was to supply water-based recreation facilities and stimulate the economy of the region (Alberta, Department of Environment, Planning Division 1975a, p.2). In essence, the seven-volume Red Deer River Flow Regulation Planning Study was a comparative evaluation of two dam sites: "site 6", 24 km west of Innis-

fail and "site 7", 32 km west of Innisfail. The study recommended development of a reservoir at "site 6" in order to "provide a multi-purpose development and to ensure that water supply will not be a limiting factor to growth within the basin" (Alberta, Department of Environment, Planning Division 1975a, p.69).

The first set of Red Deer Dam public hearings was held by the ECA at various locations in the Red Deer River basin in November and December of 1975. Public opposition to both "site 6" and "site 7" and concern that alternative approaches to flow regulation had not been explored, led the ECA to request that more comprehensive studies be undertaken to examine potential damsites upstream from Sundre, alternatives to on-stream reservoirs, and the development of integrated strategies for land use and watershed management in the Red Deer River basin (Alberta, Environment Conservation Authority 1976a, 1976b). In 1976, three additional reports were prepared by the Planning Division: Red Deer River, Today and Tommorrow: A Management Statement (1976a), Alternatives to a Dam on the Red Deer River (1976b) and Preliminary Planning Report on Potential Damsites Upstream from Sundre (1976c).

A second set of public hearings was conducted by the ECA in March, 1977 to assess the social, economic and environmental impacts of proposals for alternative dam sites, including sites above Sundre and to consider alternative approaches to impoundment structures for flow regulation in relation to the overall strategies for land use and watershed management in the Red Deer River basin. Following these hearings, the ECA recommended that no dam should be constructed at either "site 6" or "site 7" as a result of the "apparent lack of justification for increased minimum flow for any purpose other than quality improvement and

poor prospects for secondary benefits such as major recreational or power generation, or improved flood or erosion control" (Alberta, Environment Conservation Authority 1977, p.108). The ECA recommended alternative measures to improve Red Deer River basin management by integrated land use and water management (Alberta, Environment Conservation Authority 1977).

In spite of the ECA recommendations, the Alberta government has decided to proceed with construction of the Red Deer Dam. A project manager has been hired and final design of the dam is under study (Alberta 1978), but has not yet been announced.

b) Effects of the Dam on Drumheller Floods

Research conducted by the Alberta, Department of the Environment, Planning Division indicated that the Red Deer Dam capability to control Drumheller floods will be limited. Since "enhancement of water supplies and recreation potential" are the primary purposes of the reservoir, water levels will be high during spring and summer when flooding of the Red Deer River occurs. "During the flood season the reservoir will be at FSL (full storage level) and will have no storage available" (Alberta, Department of Environment, Planning Division 1975b, p.104). If flood warnings are provided 54 hours in advance of a flood,[3] it will be possible to draw down the reservoir to reduce the 1:100 year flood

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[3]The 1979 Proposed Drumheller Flood Control Study: Terms of Reference indicated that a 42-hour warning is necessary for maximum reservoir drawdown (Alberta, Department of Environment, Planning Division 1979, p.3).

peak of 1,574 m^3/sec to 894 m^3/sec and the 1:50 year flood peak of 1,379 m^3/sec to 792 m^3/sec at the City of Red Deer (Alberta, Department of Environment, Planning Division 1975a, p.65). The Alberta government reports gave no indication about whether a 54-hour lead time would be available in the foothills of the Rocky Mountains under normal hydrological conditions.

c) Drumheller Flood Protection Study

When it became apparent that the Red Deer Dam would not significantly reduce the Drumheller Valley flood hazard, the Alberta Department of the Environment, Planning Division hired Klohn Leonoff Consultants to "determine the feasibility of alternative means of reducing damages from the 1:100 year flood in developed areas of the City of Drumheller" (Klohn Leonoff Consultants Limited 1977, appendix 1). Two reports were produced. The first (Klohn Leonoff Consultants Limited 1976), proposed a series of dykes to protect the area from Nacmine to Cambria from the 1:100 year flood at a cost of approximately $4 million. Annual maintenance costs were estimated to be about $0.5 million. Without the dykes, the 1:100 year flood damages were estimated to be $5.9 million; with dykes, they were estimated to be $0.5 million (Table 4.3). The second report (Klohn Leonoff Consultants Limited 1977), proposed a series of dykes to protect the same area from the 1:100 year flood that would occur after the Red Deer Dam is built. Construction cost was estimated to be $0.4 million. Without dykes, the 1:100 year flood damages were estimated to be $3.5 million; with the dykes, they were estimated to be $0.3 million. Thus, according to the Klohn Leonoff studies, when the dam is built, smaller dykes would provide more protection from the

Table 4.3

DAMAGES RESULTING FROM A 1:100 YEAR FLOOD AND FLOOD PROTECTION COSTS IN THE DRUMHELLER VALLEY (NACMINE TO CAMBRIA)

	Red Deer Dam[a] is not built	Red Deer Dam[b] is built
Damages		
i) dykes are not built	$5,892,000	$3,493,500
ii) dykes are built	501,100	291,300
Dyke Cost		
i) construction	$3,999,670	$3,670,345
ii) annual maintenance	456,727	419,183

Source: a) Klohn Leonoff Consultants Limited 1976, pp. 23-24.

b) Klohn Leonoff Consultants Limited 1977, pp. 3-4.

1:100 year flood for developed areas of the Drumheller Valley flood plain at a slightly lower cost.

However, using the Klohn Leonoff estimates, if one assumes any significant opportunity value for the money invested, flood protection with or without the dam is more expensive than the flood damages (Table 4.4). If construction and maintenance costs are invested at 10% interest rate, compounded annually, which is a conservative rate in present market conditions, in three years, the original investment would be worth more than the estimated 1:100 year flood damages. In ten years, it would be worth $17.7 million, three times the estimated 1:100 year flood damages. In fifty years, it would be worth $1 billion or 166 times the estimated 1:100 year flood damages. According to the Klohn Leonoff estimates, if the Red Deer Dam is built, the cost of constructing the works to protect the Drumheller Valley would be higher than the estimated damage costs of a 1:100 year flood, if the dykes were not built. In fifty years, at a 10% interest rate, the original investment and accumulated annual maintenance costs would be worth $918 million or 263 times the estimated 1:100 year flood damage costs. Because the cost of the protective works recommended by Klohn Leonoff is very high compared to the value of the property being protected, less costly measures, such as flood proofing and land use management should be thoroughly investigated and evaluated before protective works are constructed.

d) Drumheller Flood Control Study

As part of the current Drumheller Flood Control Study, structural flood control alternatives are being investigated by the Alberta Department of the Environment, Planning Division, for "the protection of urban

Table 4.4

OPPORTUNITY VALUE FOR MONEY INVESTED IN FLOOD PROTECTION COMPARED TO 1:100 YEAR FLOOD DAMAGE COSTS ESTIMATED FOR THE DRUMHELLER VALLEY

	Red Deer Dam is not built	Red Deer Dam is built
1:100 year flood damages without dykes	$ 5,892,000[a]	$ 3,493,500[b]
original construction cost of dykes	3,999,670[a]	3,670,345[b]
annual maintenance cost of dykes	456,727[a]	419,183[b]
construction and maintenance costs invested at 10% interest, compounded annually, return after - 2 years	5,798,728[c]	5,321,504[c]
3 years	6,835,727[c]	6,272,837[c]
10 years	17,653,170[c]	16,200,845[c]
50 years	1,001,095,291[c]	918,823,929[c]

Source: a) Klohn Leonoff Consultants Limited 1976, pp. 23-24.

b) Klohn Leonoff Consultants Limited 1976, pp. 3-4.

c) Calculated by the author.

Note: A "nominal" interest rate of 10% was used in these calculations. The return on the investment would be somewhat lower, if a "real" interest rate, such as 5% was used.

areas within the Drumheller Valley flood plain". Dyking is only to be considered for the protection of existing flood plain development. Klohn Leonoff Consultants Limited has been contracted to update the 1976-77 dyking study and to aid in the evaluation of various flood control options, including flood proofing and land use control (Alberta, Department of Environment, Planning Division 1979, p.8).

4.3.6 Flood Proofing and Land Use Management

In Alberta, until recently, flood proofing has been left up to the individual land owner. Under the new Planning Act (1977), enforcement of flood proofing is a municipal responsibility and the owner pays the full cost. City of Drumheller officials estimated that ten percent of flood plain buildings are flood proofed in the city, most frequently by elevating structures on fill (James F. MacLaren Limited 1978, p.C-28). Several homes which were built following the 1950s floods were observed to be raised on fill or to have basement window closures or retaining walls which could serve as dykes. However, most flood plain buildings showed no visible evidence of flood proofing. The feasibility of flood proofing is being studied by Klohn Leonoff as part of the Drumheller Flood Control Study. The legal framework and potential for flood proofing new and existing flood plain development is discussed more comprehensively in chapters five, six and seven.

In Alberta, land use decisions are made at the municipal government level, within the framework provided by the Planning Act (1977). Until recently, there was no framework to provide for special planning of flood prone areas of the province. The legal framework and potential for managing flood plain development in the Drumheller Valley were studied

by the author as part of the Drumheller Flood Control Study. These are discussed in chapters five, six and seven.

4.4 Discussion

The range of physical adjustments and institutional arrangements are summarized in Figure 4.3 using the "range of choice" framework discussed in chapter three. These adjustments are grouped into four categories: those used in the past, those adopted, those under study and those not considered.

In the past, emergency action, evacuation and emergency relief programs were used most frequently to cope with flood waters. Correspondence with local insurance brokers revealed that flood insurance was available in the past, but can no longer be purchased (Rutz 1979; Sheddy 1979). For the most part, flood plain occupants bear the cost of flood damages, unless relief is provided. In the City of Drumheller, some of the low-lying riverside property is owned by the City and used for parkland or recreation facilities. During past floods, these areas were inundated and they provided a buffer zone which prevented damage to private structures. As a result of frequent flooding, Michichi Creek was channelized through North Drumheller, a dyke was built to protect low-lying parts of East Coulee and some landowners flood proofed dwellings and commercial structures in the 1950s. These measures were implemented by private individuals or the municipal government.

Most existing measures to cope with potential flood damages have been initiated by the Alberta government as part of province-wide programs, and in two cases by the federal government as part of nation-wide cost-sharing programs. These include flow forecasting, emergency action,

Figure 4.3

DRUMHELLER VALLEY FLOOD HAZARD ADJUSTMENTS

	Used in the Past	Existing	Under Study	Not Considered
Modify the Cause				
watershed management			●	
weather modification				●
Modify the Hazard				
dam			●	
dyke		●	●	
channelization		●		
stream diversion				●
Modify the Loss Potential				
flood forecasting		●		
flood proofing	●	●	●	
emergency action	●	●		
land use management		●	●	
permanent evacuation	●			●
development policies		●		
warning signs				●
public education			●	
Adjust to the Loss				
Spread the Loss				
subsidized insurance		●		●
public relief		●		
tax adjustments				●
public land purchase	●		●	
Plan for the Loss				
private insurance	●			●
reschedule production				●
Bear the Loss	●			

public relief and crop insurance programs. Flood plain land use policies and flood proofing policies have been required for Alberta municipalities by the Planning Act (1977).

The Drumheller Flood Control Study, which is examining measures to cope with all aspects of the range of choice is promoted and organized by the provincial government, with limited municipal input and commitment. This flood control study is important in this regard, because it has not been undertaken in the wake of a flood disaster or in an area where flooding has been a persistent problem in recent years. Its impetus is political, since it occurred because the Red Deer Dam will not afford the flood protection for the Drumheller Valley that was originally anticipated.

Eight adjustments of the theoretical range of choice outlined in chapter three have not been considered in the Drumheller Valley. Weather modification and stream diversions are not physically possible at present. Permanent evacuation and warning signs and rescheduling production have not been used, probably because there have been no recent floods. Private insurance is no longer available, and government subsidized insurance is only available for agricultural crops, not flood plain buildings. Tax adjustments to encourage flood-compatable land uses have never been used in Alberta.

The actual responsibility for reducing flood damage potential, with or without flood protection, lies with the municipalities, because the municipal government is responsible for controlling land use on the flood plain. The municipalities must be committed to a policy to reduce the rate of flood plain development. Otherwise, programs such as disaster relief and flood protection, provided by the provincial or federal

governments, will have limited effectiveness. This has been well documented in the United States, where flood plains developed more quickly than they could be protected and flood damage relief payments rose, despite billions of dollars spent on flood protection (U.S., Water Resources Council 1976, p.II-2). Thus, in the following three chapters, federal-provincial programs, provincial legislation and municipal bylaws, which affect the Drumheller Valley flood plain land use policy are examined. Alternative land use policies for vacant and subdivided flood plain land are suggested, and then, these policies are considered for each of the ten Drumheller Valley communities.

CHAPTER V

LEGISLATION AND BYLAWS AFFECTING DRUMHELLER VALLEY FLOOD PLAIN LAND USE

5.1 Introduction

The potential and existing means of managing Drumheller Valley flood plain land use are affected by laws and agreements made at the federal, provincial and municipal levels of government. As discussed in the previous chapter, Alberta participates in two federal-provincial programs to reduce the cost of flood damage: crop insurance and disaster assistance. However, the province has not yet joined the National Flood Damage Reduction Program, which is aimed at managing new and existing flood plain development.

Six Alberta statutes provide the legal framework for controlling development and use of flood plain land: The Planning Act (1977), The Department of Environment Act (1971), The Water Resources Act (1970), The Improvement Districts Act (1970), The Municipal Government Act (1968) and The Plumbing and Drainage Act (1977). These statutes provide the legal basis for a number of flood plain land use adjustments which are, or could be, initiated by the Alberta government: public purchase, restricted development and removal of dilapidated buildings. At the municipal level, in the City of Drumheller and I.D. No. 7, the provincial statutes provide the legal basis for: municipal purchase of flood plain land, approval or refusal of subdivision applications for flood plain development by the PRPC, approval of new development by the municipality, designation of the flood plain as environmental reserve, and requirements

for gate valves on sewage systems.

The Drumheller Valley is located within two municipalities, the City of Drumheller and I.D. No. 7, both of which are within the PRPC planning area. The PRPC, which is formed of representatives of the municipal councils within its planning region, is responsible, on the advice of its planning staff, for approving all subdivision within its planning area, for providing planning assistance to the municipalities and for preparing a regional plan (The Planning Act 1977, section 26). Thus, the Commission is instrumental in controlling new subdivision of the flood plain, in advising municipal authorities on matters relating to development of flood plain land, and for stating the policy towards flood plain subdivision and development in the regional plan. The PRPC was incorporated in May 1978; at present, a regional plan has not been formulated, but under the Planning Act (1977), a regional plan must be in force by 1982.

City of Drumheller development is regulated by the City of Drumheller Development Control Bylaw (1976) and I.D. No. 7 development is regulated by the I.D. No. 7 Development Control Bylaw, Directions in Force (1978). In order to develop land in the City of Drumheller and I.D. No. 7, a development permit must be awarded by the Development Control Officer (in the case of single family dwellings that are not "deemed approved", signs or accessory buildings) or the Municipal Planning Commission (in all other cases) (City of Drumheller Development

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[1]Prior to May, 1978, the CRPC was the planning advisor to the City of Drumheller and I.D. No. 7.

Control Bylaw, resolution 3; I.D. No. 7 Development Control Bylaw, direction 3). Construction cannot commence until a building permit has been issued. In addition, the General Plan Bylaw (1977a), prepared by the CRPC as part of the Drumheller Valley Planning Study (1977a, 1978), has been adopted by both municipalities. Each of these three documents has a section, or sections, pertaining to flood plain development in the Drumheller Valley.

5.2 The National Flood Damage Reduction Program

According to the Federal Policy Statement on Inland Waters, the "federal government is committed to alleviating human suffering and minimizing the costs of damages caused by floods through strategies such as discouragement of new investment in identified flood risk areas" (Canada, Department of Fisheries and Environment 1978a). In 1973, the federal government embarked on a National Flood Damage Reduction Program, administered by the Department of Environment, to provide the framework for a coordinated federal-provincial approach to flooding (Canada, Department of Fisheries and Environment 1978b, p.93). The National Flood Damage Reduction Program follows the cooperative approach of the Canada Water Act (1970), and is based on the following principles:

1. programs of federal agencies concerned with flooding must be coordinated internally and with related provincial programs;
2. flood risk areas must be clearly defined and mapped;
3. flood hazard information must be communicated to the public, industry and municipalities;
4. construction of federal facilities and federal grants and loans should not be allowed in flood risk areas, or should be made conditional upon adequate flood proofing

or damage reduction measures;[2]

5. disaster assistance should be denied for further development in identified flood risk areas; and
6. provinces and municipalities should be encouraged to consider appropriate restrictions on land use in high-risk areas.

(Canada, Department of Fisheries and Environment 1976, p.90; Spargo and Watt 1977, p.78)

Under the British North America Acts (1967 to 1965), most natural resources, including land and water which lie within provincial boundaries are under provincial jurisdiction (Canada, Department of Environment 1972, p.3). In order to undertake a National Flood Damage Reduction Program, the federal government must negotiate separate flood damage reduction agreements with each province. Several types of agreement may be made. In a "general agreement", which has a life of ten years, the basic approach for reducing potential flood damages is defined. Separate "annex agreements" cover flood risk mapping programs, flood damage reduction studies, cooperative flood forecasting and warning services, and programs to implement optimum strategies for flood protection in high-risk areas (Canada, Department of Fisheries and Environment 1976, p.90; Canada, Department of Fisheries and Environment 1978c, p.9). Presently, general agreements and/or flood risk mapping agreements have been made with Manitoba, Saskatchewan, New Brunswick, Nova Scotia, Quebec, and Ontario, and are being negotiated with British Columbia and Alberta (Canada, Department of Fisheries and Environment

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[2]Central Mortgage and Housing Corporation will not give financial assistance to undertakings in designated flood-risk areas, nor will the Department for Regional Economic Expansion give development incentives for facilities located in such areas (Bruce et al. 1977, p.59).

1978b, pp.8-12).

The province of Alberta is currently negotiating a "general flood damage reduction agreement" with the Canadian government. Because the Alberta Department of the Environment has undertaken, and almost completed, a flood plain mapping program for major urban centers in the province, including the Drumheller Valley, the proposed agreement places less stress on the flood plain mapping aspect and more emphasis on flood forecasting, management policies, flood control projects and public land purchase (Bailey 1979). Although a flood damage reduction agreement has not been negotiated, Central Mortgage and Housing Corporation will not give financial assistance for undertakings on the 1:50 year flood plain, as designated on the Alberta flood plain maps (Van Brederode 1979).

Thus, at the present time, flood plain land use management in the Drumheller Valley is not affected by the National Flood Damage Reduction Program. If an agreement between the federal and provincial governments is reached in the near future, land use management policies and associated adjustments, such as flood forecasting, flood control projects and public land purchase in the Drumheller Valley may be affected by the terms of the agreement.

5.3 Alberta Statutes

5.3.1 The Planning Act

a) Subdivision Regulations (sections 6 and 8)

The PRPC must consider potential flooding when deciding whether or not to approve an urban subdivision application (section 8). The PRPC staff is opposed to subdivision for residential and certain other pur-

poses within the 1:100 year flood plain, unless flood proofing measures are undertaken to the satisfaction of relevant authorities. However, the decision of the PRPC may be appealed to the Alberta Planning Board "which has on occasion approved subdivision previously refused by the PRPC because of flood risk" (Fenwick 1979a). Although it is not required by the Planning Act, it is the practice of the PRPC to refer all urban subdivision applications, in areas which may be subject to flooding to Alberta Department of the Environment for comment.

The Planning Act (section 8) stipulates that the PRPC must send a copy of all subdivision applications for rural areas within 0.5 miles (0.8 km) from the bed and shore of a permanent water body, to the Deputy Minister of Environment for comment. Although potential flooding must be considered, the PRPC is not bound by the Deputy Minister's comments. The flood hazard is only one of many factors to be considered when approving a subdivision application, and in itself, may not be sufficient to prevent subdivision of flood plain land. If the decision of the regional planning commission to disallow a flood plain subdivision is appealed to the Alberta Planning Board, it may or may not be overturned.

As the subdivision approving authority, the PRPC may exercise some control over development of flood plain land through a legal "development agreement". For example, the PRPC may approve a flood plain subdivision, if development is restricted in certain ways, perhaps through flood proofing structures or raising the land with fill. However, separate agreements are negotiated with each developer; thus, development agreements do not provide a consistent flood plain management policy. Effectiveness may be hampered by compromise and by precedent.

Under the Planning Act (1977), the PRPC approves only subdivision of land, not development. Thus, construction may occur on flood plain land which is already subdivided without comment or approval from the regional planning commission or the Alberta Department of the Environment. For example, new homes have been constructed beside the Red Deer River in 1977 and 1978 on previously subdivided lots in every Drumheller Valley community without flood proofing. This problem is discussed in more detail in chapter seven.

b) Environmental Reserve (sections 92, 95, 107 and 115)

The PRPC may require the subdivision applicant to provide environmental reserve land without compensation. This has only been possible since the new Planning Act was adopted. The following land may be required as environmental reserve: land subject to flooding, land unsuitable for development in its natural state, or a strip of land not less than 20 feet (6.1 m) in width, abutting the bed and shore of any lake, river, stream or other water body to prevent pollution and to provide public access to the waterbody. Reserve land is owned by the municipality, but uses are defined by the Planning Act (section 107.1): a public park or left in a natural state. Environmental reserve, once established, may not be sold, leased or otherwise disposed of (section 115). It is the present policy of the PRPC to require a designated width of environmental reserve from each flood plain subdivision. The actual width is not consistent, either according to distance or flood frequency, but it generally exceeds the minimum 20-foot (6.1 m) reserve (Fenwick 1979b).

Environmental reserve could be used by the PRPC to prevent subdivision of land below a certain flood frequency, if a two-zone flood plain management policy is adopted. The innermost zone (the floodway) could be taken from new subdivisions as environmental reserve, but subdivision could be allowed in the fringe areas, if buildings are raised on fill or flood proofed in other ways.

c) Cash in Lieu of Municipal Reserve (sections 96 and 97)

The municipalities could use money acquired as cash in lieu of municipal or school reserve when land that is not on the flood plain is subdivided to purchase land adjacent to water courses. This would enable either the City of Drumheller or I.D. No. 7 to increase its share of recreational or open space land on the flood plain. This has not been done in the Drumheller Valley.

d) Flood Plain Development (section 67)

According to the Planning Act, the land use bylaw prepared by the municipality may make provisions for the development of buildings on land subject to flooding, either generally, or with respect to any land use district or part district established by the land use bylaw. Moreover, the municipality may make similar provisions pertaining to development within a specified distance of the bed or shore of a waterbody. Municipalities are likely to incur losses, such as damage to roads and utilities as a result of flooding. "Save harmless" agreements are often used by the municipality to ensure that it is not held liable for development allowed on a designated flood plain (Fenwick 1979b).

In the Drumheller Valley, development of the flood plain, after it is subdivided, is regulated by the City of Drumheller and the I.D. No. 7 Administration through development control bylaws. New developments in the flood plain do not have to be approved by either the regional planning commission or by the Alberta Department of the Environment. Thus, positive support for flood plain management by the municipality is essential.

5.3.2 Department of Environment Act

a) Purchase or Expropriation of Land (section 9)

The Minister of the Environment may purchase or expropriate any land or associated personal property for the "purpose of any program or development project relating to the conservation, utilization or management of natural resources", for "environmental conservation or improvement" or for any matter under his administration. The land acquired is administered by the Minister of Energy and Natural Resources, unless the Lieutenant Governor in Council directs otherwise.

Since control of flood plain development can be justified as resource management or environmental conservation, the Minister of Environment has the power, under section 9, to expropriate or purchase flood plain land. The Department of Environment owns no land in the Drumheller Valley for flood damage reduction purposes, and it is unlikely that the Minister would use section 9 to purchase flood plain land because under the Water Resources Act (1970), which is also administered by the Alberta Department of the Environment, the Minister has the explicit power to purchase flood plain land.

b) Restricted Development Areas (section 15)

At the recommendation of the Minister of the Environment, the Lieutenant Governor in Council may establish a restricted development area to "control and regulate development and use of the area" in "the public interest". Flood plain land could be designated as a restricted development area for the purposes of: "protecting the watershed in or adjacent to the area" and "retaining the environment in a natural state or a state suitable for recreation or the propogation of plant and animal life". After a restricted development area is established, the Lieutenant Governor in Council may, by regulation, provide for the "control, restriction or prohibition of any kind of use, development or occupation of land" in the restricted development area; allow the Minister of the Environment to "consent, approve or exempt uses" of land in the restricted development area; provide for the "removal of buildings, improvement, removal of materials or animals and payment of compensation"; and authorize the Minister of the Environment to purchase or expropriate any "estate or interest in land" in the restricted development area.

The Drumheller Valley flood plain is not a restricted development area. A restricted development area would be most readily established in undeveloped areas where a high proportion of land is already publicly owned. Public opposition to a policy of land use restriction on private land or to land expropriation could be anticipated, unless implementation followed a major flood. In this case, flood plain occupants would likely be more willing to cooperate to prevent future flood damages, as has been documented in Ontario following the 1954 Hurricane Hazel (Giles 1976, p.16) and the 1974 Grand River Flood (Mitchell

et al. 1978).

5.3.3 The Water Resources Act

a) Designation of Flood Control Areas (section 97)

The Lieutenant Governor in Council may, by regulation, designate any areas of the province considered to be "in serious danger of flooding" as flood control areas. Within a flood control area, the Minister of Environment may purchase or expropriate land for any project that he considers will lessen the danger from floods or to prevent lands from being used for any purpose while danger from flooding exists. However, without purchase or expropriation, the Minister may prohibit or regulate the use of land in a flood control area, if the flood danger is a serious hazard to life or property; or he may order removal of structures within the flood control area, if reasonable protection cannot be provided for the structures and contents. In all cases, the owner would be compensated for the loss. If a land owner contravenes an order of the Minister regarding land use or structure removal, the owner is not entitled to compensation for any loss. Moreover, the Minister may have a structure remaining, in contravention of his order, or built in contravention of his order, removed.

Thus, in addition to the power to expropriate or purchase land for conservation and resource management under the Department of Environment Act, the Minister of Environment may expropriate land specifically for flood control purposes under section 97 of the Water Resources Act. This could include land for dykes, levees or flood control reservoirs, or land where uses and development would be restricted. An example of public purchase is the purchase of 2,834 hectares of flood plain land

on the south shore of Lesser Slave Lake by the Department of the Environment between 1968 and 1976. Presently, the land is owned by the government and leased to the farmers for agricultural use.

The Drumheller Valley flood plain has not been designated as a flood control area. Public opposition towards purchase of the Drumheller Valley flood plain can be anticipated, particularly in densely populated urban areas, where purchase of homes and relocation of residents would be necessary, and in areas adjacent to urban development where speculative profits through subdivision and ensuing development are anticipated by the landowner. In some rural areas, where agricultural uses predominate and frequent flooding occurs, such as Lesser Slave Lake, farmers seem to be more willing to cooperate with public purchase of agricultural land (Hu Harries and Associates 1977).

5.3.4 The Improvement Districts Act

The Improvement Districts Act (1970), administered by the Minister of Municipal Affairs, cannot be used to regulate flood plain development. However, in one section, there are provisions that could be used by the provincial government to manage flood plain uses, particularly in the Drumheller Valley.

a) Dilapidated Buildings (section 29)

If an unoccupied building is dangerous to public safety or health, the Minister of Municipal Affairs may require the owner to repair, remove or demolish the structure. If the owner does not comply, the Minister must sell, demolish or repair the structure. The proceeds from the sale or charge for remedy will go to the owner.

In I.D. No. 7, there was a high proportion of unoccupied, dilapidated buildings, especially on the flood plain, in 1978. However, the Minister of Municipal Affairs has not required their removal. Some vacated squatter's shacks or unoccupied structures of absentee landowners fall into this category, particularly in the hamlet of East Coulee where thirty of the dwellings on the flood plain were found to be unoccupied. Not only are these buildings unsightly, but in the event of a flood, floating debris from these buildings could pose a threat to human life or to other flood plain buildings.

5.3.5 The Municipal Government Act

a) Acquisition of Land (section 127)

The municipality has the power to purchase land for any municipal purpose, which could include flood plain management. In Drumheller, the City owns parkland adjacent to the river. If the City expands, it would have the opportunity to purchase additional undeveloped flood plain land.

In order to reduce the potential flood hazard, the municipality need not purchase the entire 1:100 year flood plain. This would undoubtedly result in significant public opposition. Purchase of a narrower buffer zone combined with flood proofing and land use zoning could provide a certain degree of protection and prevent development up to the river edge where erosion is an additional problem.

b) Installation of Gate Valves (regulations)

The Plumbing and Drainage Act Regulations allow the plumbing inspector to require developers to provide a degree of flood proofing by

installing gate valves to prevent or reduce basement flooding from sewage systems in the event of a flood. This could be accomplished during construction at a relatively low cost and would reduce the damage potential to buildings not actually flooded by surface water. If installed during construction, public opposition owing to the cost would be avoided. However, the builder may object if such valves would indicate a hazard to potential buyers.

5.4 Municipal Bylaws

5.4.1 The City of Drumheller Development Control Bylaw

a) Land Near Water or Subject to Flooding or Subsidence (resolution 2.14)

The development of land subject to flooding is to be "discouraged" in the City of Drumheller. But, if development is allowed, the developer cannot hold the municipality responsible for any damage to or loss of the development caused by flooding. Moreover, if a structure is approved adjacent to a watercourse, it must be sited at least 125 feet (38.1 m) from the watercourse. This setback requirement may be overruled by a Development Appeal Board decision.

b) Development Permits not Required (resolution 2.2.1)

Under the present bylaw, single family dwellings, excluding modular homes of 1,000 square feet (92.9 square meters) are "deemed approved" in appropriate land use districts; that is, no development permit is required. The Director of the PRPC noted that:

> In the future, for single family homes within new subdivisions which require special treatment as a result of potential flood risk ..., it would be worth considering a requirement for a development permit.
>
> (Fenwick 1979a)

Although flood plain development is to be "discouraged" in the City of Drumheller, it is not prevented because single family residential developments are allowed to be constructed without a development permit. The City will not be held responsible for property damages to new developments resulting from floodwaters on the designated flood plain, even though it has allowed the development to take place. Nevertheless, the property owner would almost certainly be the recipient of various forms of relief if flood damages occurred.

5.4.2 I.D. No. 7 Development Control Bylaw, Directions in Force

a) Land Near Water or Subject to Flooding or Subsidence (direction 2.8)

In I.D. No. 7, the 1:100 year flood plain, as determined by the Alberta Department of the Environment, shall not be developed unless sufficient landfill can be provided to raise the area above the flood level or suitable flood proofing techniques are employed to the satisfaction of the Alberta Department of the Environment and the Municipal Planning Commission. As in the City of Drumheller, the development of land subject to flooding is to be "discouraged" in I.D. No. 7. But, if development of the flood plain is allowed, "the developer shall by agreement indemnify the I.D. from any damage to or loss of the development caused by flooding". This is called a "save harmless" agreement. If a structure is approved adjacent to a watercourse, it must be sited at least 125 feet (38.1 m) from the watercourse. This setback require-

ment may be overruled by a Development Appeal Board decision.

5.4.3 General Plan Bylaw: City of Drumheller and I.D. No. 7

The Drumheller Valley General Plan (CRPC 1977a) was adopted as a bylaw by the City of Drumheller and the Minister of Municipal Affairs on behalf of I.D. No. 7 in 1978. The following recommendations were accepted by the two municipalities:

> Recommendation 1 - The City of Drumheller, I.D. No. 7 Administration and Alberta Environment should establish a joint policy for development in the Red Deer River flood plain. The policy should reflect the degree of flood for any given area and outline the various protective measures required for proposed land uses.
>
> Recommendation 31 - Development of land along the Red Deer and Rosebud Rivers for recreation purposes should be encouraged, with particular emphasis given to the integration of park sites through the establishment of a continuous public footpath system.
>
> Recommendation 37 - Reflecting development constraints posed by utility servicing, transportation facilities, and future commercial development, the City of Drumheller and I.D. No. 7 Administration should consider the advantages of developing sites identified along the valley floor of the Red Deer River prior to encouraging major urban growth on the benchlands.

The General Plan Bylaw outlines policies which form the basis for an environmental policy for the Drumheller Valley:

> Policy a - New subdivision and development should not be permitted within the 1:100 year flood plain of the Red Deer River unless suitable means of flood protection are provided in conformity with a flood plain development policy to be formulated through discussions between the Improvement District Administration, City of Drumheller, Alberta Environment and affected citizens.
>
> Policy c - The rich flood plain land within the Drumheller Valley should be preserved for agricultural and recreational purposes.

The long-term land use development strategy stated in the General Plan outlines development strategies for the Drumheller Valley and includes a section on development of the flood plain:

> Development Criterion b - Land within the 1:100 year flood plain as defined by Alberta Environment is considered undevelopable unless sufficient landfill can be provided to raise the area above the flood level or other suitable techniques are employed to the satisfaction of Alberta Environment. Sites which could be raised above the flood level with the addition of 4 feet [1.2 m] of fill are included as potentially developable.

Thus, the General Plan states that recreation and agricultural use of flood plain land should be encouraged. However, by indicating that valley floor sites should be developed before benchland sites, because of the difficulty of servicing lots, transportation and potential undermining, the bylaw could be increasing development pressure on flood plain lands. The position of the General Plan Bylaw regarding flood plain development is unclear. The bylaw states that new development of the 1:100 year flood plain should not be allowed unless it conforms to a flood plain development policy to be formulated by Alberta Environment, the City of Drumheller, the I.D. No. 7 Administration and the affected citizens. Although such a policy has not been formulated yet, the General Plan states that if sufficient land fill can be provided or if flood proofing techniques are utilized, flood plain sites are developable. In effect, the General Plan is anticipating the flood plain policy by stating that development must conform to the future plan, and later stating the development conditions.

The present policy for flood plain development in the Drumheller Valley, as outlined by the City of Drumheller and I.D. No. 7 development control bylaws and the General Plan is unclear. The confusion results

because the development control bylaws have not been ammended to conform with the General Plan Bylaw. It is not clear whether the flood plain is not to be developed before a flood plain policy is established (General Plan, recommendation 1), or whether it is developable with fill or flood proofing approved by the Alberta Department of the Environment (General Plan, development criterion b; I.D. No. 7 Development Control Bylaw, direction 2.8), or whether the flood plain can be developed without protective measures, provided buildings are located 125 feet (38.1 m) away from the river course, in which case the municipality would not be responsible for flood-induced damages (City of Drumheller Development Control Bylaw, resolution 2.1; I.D. No. 7 Development Control Bylaw, direction 2.8). When the flood plain development policy is adopted following the completion of the Drumheller Valley Flood Control Study, these questions should be answered. When the flood plain development policy is incorporated into the Palliser Regional Plan, it would take precedence over local land use bylaws and plans. In the interim, municipal councils and landowners of flood plain land may have difficulty interpreting the conflicting bylaws and deciding which takes precedence.

According to the PRPC, which approves all subdivision applications and advises the municipalities about development, the current policy is as follows:

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[3]It should be noted that the PRPC is reviewing the General Plan and is preparing new land use bylaws for the two municipalities, to be completed by April, 1980 (Fenwick 1979c).

1. the commission is opposed to subdivision of the flood plain for residential and certain other purposes;
2. the set-back requirements are followed by the City and Improvement District, subject to appeal to the Development Appeal Board; and
3. land fill requirements are applied at the 1:100 year flood level, which is consistent with the General Plan.

(Fenwick 1979a)

5.5 Discussion

Alberta has not joined the National Flood Damage Reduction Program. If an agreement between the federal and provincial governments is reached, land use management policies, and other adjustments such as flood forecasting, flood control projects and public land purchase in the Drumheller Valley may be affected by the terms of the agreement.

Alberta statutes allow the Alberta Department of the Environment or the municipal governments to purchase flood plain land or to regulate its use. However, these powers have been implemented rarely in the province. Opposition by municipal governments and landowners to land purchase, expropriation and land use regulation could be anticipated in an area such as the Drumheller Valley which has not experienced a severe flood for 25 years, particularly when it would involve dislocation of homes and families or decreased land values.

Generally, flood plain land uses are regulated at the municipal government level. Decisions regarding subdivision are made by the regional planning commission, decisions regarding development are made by the municipalities. The Alberta Department of the Environment, River Engineering Branch has prepared flood plain maps for the Drumheller Valley, which the regional planning commission and the municipalities may use as a guideline to the location of the flood plain. These are

being updated as part of the Drumheller Valley Flood Control Study. Also, the Alberta Department of the Environment may provide advice about proposed subdivision and development of the flood plain. However, the final decision rests with the regional planning commission and the municipality, unless it is overturned by a Development Appeal Board decision.

The City of Drumheller and I.D. No. 7 do not have clear flood plain management policies. The municipalities may disallow flood plain development, purchase flood plain land, request designation of the flood plain as environmental reserve and allow development with fill and flood proofing. Neither municipality will take responsibility for development allowed on the flood plain. The current Drumheller Flood Control Study may provide the basis for adoption of a coordinated program when municipal bylaws are amended and the regional plan is adopted in the next several years.

It can be argued that the provincial and federal governments should not interfere in municipal land use decisions. However, in the case of flood plains, they have a vested interest. The municipality has the power to state that it will not accept responsibility for flood-induced damages to development which it allows on the flood plain. The Alberta government, and in some cases the federal government, pay the costs of flood forecasting, emergency preparation programs, relief programs and flood control measures. These programs would not be necessary if there was no development on the flood plains of the province. Thus, the provincial and federal governments have an interest in reducing the potential for flood damage and the associated cost paid by society as a whole.

Clearly, the first step which should be taken by the provincial government, since it has not joined the federal flood damage reduction program which has adopted a definition of flood plain, is to provide the municipalities with a legal, clear definition of "flood plain" which could be incorporated into regional plans, general plans and municipal bylaws. Under the Planning Act (1977), the subdivision approving authority must consider "potential flooding" and the land use bylaws may make provisions for development of buildings on land "subject to flooding". These concepts are, at best, vague; there is no clear indication of what flood level is to be considered. In practice, the 1:100 year flood plain is most frequently used for planning purposes in Alberta. However, this practice warrants careful investigation. Public opposition to the one-zone method of controlling flood plain land has arisen, for example in the United States and Ontario where flood plain management policies have existed longer than in Alberta. A zoned flood plain, with use intensity increasing from the floodway adjacent to the river course, to the floodway fringe, at the outer edge of the flood plain has been implemented in the United States and is under study in Ontario. A clear definition, by the provincial government, of the term "flood plain" would provide the basis for municipal government planning. "Policies" and "practices" of municipalities and regional planning commissions in this regard, provide no legal basis for controlling flood plain development and have frequently been appealed with success.

Thus, in Alberta, and particularly in the Drumheller Valley, there is no clear flood plain management policy aimed at reducing potential

flood damages. The need for such a policy was recognized by the CRPC. The first recommendation of the Drumheller Valley General Plan (CRPC 1977a, p.ix) was that the "City of Drumheller, I.D. No. 7 Administration and Alberta Environment should establish a joint policy for development in the Red Deer River flood plain". In the following chapter, existing and alternative land use management policies for vacant and subdivided land on the Drumheller Valley flood plain are discussed.

CHAPTER VI

EXISTING AND ALTERNATIVE FLOOD PLAIN LAND USE POLICIES FOR THE DRUMHELLER VALLEY

6.1 Introduction

Most land use management in Alberta is undertaken at the municipal government level through municipal development control bylaws. General policies are set out by the Planning Act (1977) and guidance is provided to the municipalities by the regional planning commissions and the Alberta Department of Municipal Affairs. In the City of Drumheller and I.D. No. 7, all new subdivision of land must be approved by the PRPC. Advice may be provided to the regional planning commission by the Alberta Department of the Environment. Decisions regarding development and building permits are made at the municipal level.

In this chapter, existing and alternative land use policies are suggested for five general categories of undeveloped and developed[1] land on the Drumheller Valley flood plain (Table 6.1). The two categories for undeveloped land are: undeveloped vacant land and new subdivision applications for undeveloped land. The three categories for developed land are: vacant subdivided lots, developed subdivided lots and lots containing abandoned buildings.

Several of the suggested alternative flood plain land use policies

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[1]In this thesis, "development" is used to describe intensive use of the land for residential, commercial, industrial or other similar purposes. "Undeveloped land" is used to describe parkland, campgrounds, parking lots and other less-intensive land uses.

Table 6.1

ALTERNATIVE MEANS FOR DEVELOPING

FLOOD PLAIN LAND USE POLICIES AND ENABLING LEGISLATION

Alternative Means	Government Agency	Enabling Legislation/Bylaw
UNDEVELOPED LAND		
Vacant Undeveloped Land		
a) development control	Alberta Environment City of Drumheller and I.D. No. 7	Water Resources Act Development Control Bylaw
b) public purchase	Alberta Environment	Water Resources Act Department of Environment Act
	City of Drumheller and I.D. No. 7	Municipal Government Act
New Subdivision Applications		
a) approval/development agreement	Palliser Regional Planning Commission	Planning Act
b) environmental reserve	Palliser Regional Planning Commission	Planning Act
DEVELOPED LAND		
Vacant Subdivided Lots		
a) development approval	City of Drumheller and I.D. No. 7	Development Control Bylaw
b) public purchase	Alberta Environment	Water Resources Act Department of Environment Act
	City of Drumheller and I.D. No. 7	Municipal Government Act
Developed Subdivided Lots		
a) leave unprotected	-	-
b) flood proofing enforcement	City of Drumheller and I.D. No. 7	Planning Act Municipal Government Act
c) protection	Alberta Environment	Water Resources Act
d) public purchase	Alberta Environment	Water Resources Act Department of Environment Act
	City of Drumheller and I.D. No. 7	Municipal Government Act
Abandoned Buildings		
a) require removal	Alberta Municipal Affairs	Improvement District Act
b) public purchase	Alberta Environment	Water Resources Act Department of Environment Act
	City of Drumheller and I.D. No. 7	Municipal Government Act

are based on a two-zone flood plain. In practice, flood plain land use management is generally based on the 1:100 year flood plain in the Drumheller Valley and Alberta. Development of the 1:100 year flood plain, with flood proofing, is usually allowed; however, the Alberta Department of the Environment advises subdivision approving authorities not to allow subdivision and development in areas where backwater flooding would be caused (Hardie 1979). There are several exceptions, such as the City of Calgary, where a two-zone flood plain has been used to some extent. In this chapter, a two-zone flood plain land use policy is suggested as an alternative which may be viable in the Drumheller Valley. Since development is restricted to the valley floor, much of which is flood plain, by badland topography and undermining, it may be unreasonable to place the same development restrictions on land with a one-percent chance of annual flooding as land with a four-percent chance of annual flooding. The inner zone, or floodway, has been defined as the main channel and adjacent area that would carry a peak flow of observable velocity during a selected flood (U.S. Army Corps of Engineers 1967). It may also be defined according to a designated recurrence interval, such as the 1:25 or 1:20 year flood (Bruce et al. 1977, p.58). In the following discussion, the 1:25 year flood line was used as the boundary of the floodway because it is the best-available frequency which may approximate a floodway.[2] The outer zone, or floodway

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[2]The mean daily 1:25 year discharge of the Red Deer River at Drumheller is estimated to be 1,379 m^3/sec (Alberta Environment, Planning Division 1979). Four floods of this magnitude have been recorded or estimated at Drumheller (Table 4.3). This may, in part, explain why in some areas (Nacmine, Rosedale, Cambria and part of Newcastle), the subdivided settlement pattern appears to avoid the 1:25 year flood plain (appendices C. E. F. and G). Thus, the 1:25 year flood plain appears to be a realistic floodway designation for the Drumheller Valley.

fringe, is the area between the floodway and the outer-edge of the flood plain, in this case the 1:100 year flood line.

The legal basis for management and the existing policy for each land use category are outlined in the following section. Then, general social, economic and environmental effects of alternative flood plain land use policies are suggested for each category. Finally, the role of land use zoning in the implementation of flood plain management policies is discussed.

6.2 Existing Policies for the Land Use Categories

6.2.1 Undeveloped Land

Use of undeveloped flood plain land may be controlled by the municipalities through the development control bylaw. According to the Planning Act (1977, section 67), the municipalities may make provisions for flood plain development either generally, or with respect to any land use district or part district, established in the development control bylaw. The City and I.D. No. 7 have chosen to make general provisions for flood plain development, as was discussed in chapter five. In both municipalities, development of the flood plain is to be discouraged. If flood plain development is allowed, the set-back requirement from the watercourse is 38.1 m. If flood plain development is allowed, the developer cannot hold the municipality responsible for flood-induced losses; this is known as a "save-harmless" agreement. However, in I.D. No. 7, new flood plain development is to be flood proofed to the 1:100 year flood level.

Use of undeveloped flood plain land may also be controlled by the Alberta Department of the Environment, if the area is designated as a

"flood control area" (Water Resources Act 1970, section 97). However, the Drumheller Valley flood plain has not been designated as a flood control area because it has not experienced flooding in recent years. If several damaging floods occur in the future, control of future development by the provincial government may be considered.

Undeveloped, vacant flood plain land may be purchased to reduce future flood damages by either the Alberta Department of the Environment, under the legislative authority of the Water Resources Act (1970, section 97) and the Department of Environment Act (1970, section 9), or the municipal government under the legislative authority of the Municipal Government Act (1968, section 12). In 1978, only a small portion of the Drumheller Valley flood plain was public property, such as the Newcastle flats[3], which were owned by the City of Drumheller, the property west of North Drumheller which was owned by the federal government and used for recreational purposes (appendix D) and the recreational facilities in the City of Drumheller (appendix D).

New subdivision applications for development of the flood plain are presently controlled by the PRPC, which is the subdivision approving authority. It is the present policy of the PRPC to oppose subdivision of the 1:100 year flood plain for residential and certain other purposes unless flood proofing is undertaken to the satisfaction of relevant authorities, including the Alberta Department of the Environment (Fenwick 1979a). Subdivision of the flood plain is not allowed by the PRPC

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[3]The Newcastle flats is the low-lying area in the eastern portion of Newcastle. In 1978, it was owned by the City of Drumheller. A portion was used for a park and campground; the remainder was inhabited by squatters (appendix C).

or its advisor, the Alberta Department of the Environment, if it will cause backwater flooding from a 1:100 year flood. As discussed in the previous chapter, the PRPC may use three mechanisms to control subdivision of the flood plain. It may decide to approve or not to approve the subdivision applications. It may require part or all of the flood plain as environmental reserve. A development agreement for flood proofing may be made contingent to the subdivision approval.

6.2.2 Developed Land

Development of vacant lots in existing subdivisions must be approved by the municipal government, in most instances. As noted for undeveloped land, above, both the City of Drumheller and I.D. No. 7 development control bylaws make provisions to "discourage" new flood plain development. However, there are several differences between the bylaws of the two municipalities. In I.D. No. 7, new flood plain development is to be flood proofed to the 1:100 year flood level. In the City of Drumheller, no development permit is required to build single family dwellings in appropriate land use districts. These dwellings are "deemed approved" and may be constructed on the flood plain without approval of the City, Regional Planning Commission or provincial government.

Developed lots on the Drumheller Valley flood plain are not covered by a specific policy related to the flood hazard. Flood proofing of buildings could be required through the development control bylaw. In addition, according to the Municipal Government Act (1970, section 193), the municipal council may require gate valves to be installed to prevent flooding from the sewage system. Protection of developed land could be

provided by the Alberta Department of the Environment under the Water Resources Act (1970, section 97). Developed property could be purchased by the Alberta Department of the Environment under the Water Resources Act (1970, section 97) or the Department of Environment Act (1971, section 9) or by the appropriate municipality under the Municipal Government Act (1968, section 127).

Abandoned buildings are found throughout the Drumheller Valley, particularly in the rural areas and the hamlets. Under the Improvement Districts Act (1970, section 29), the Minister of Municipal Affairs may require the removal of dilapidated, abandoned buildings, without purchase of the property. Alternatively, the land and buildings could be purchased by the Department of the Environment or the municipality under the legislation cited in the preceding paragraph. Neither removal nor purchase of abandoned buildings have been used by the provincial government to mitigate flood damages in the Drumheller Valley.

6.3 General Effects of Alternative Land Use Policies

6.3.1 Undeveloped Vacant Land

Two alternative land use policies are suggested for vacant undeveloped land: development control and public purchase (Table 6.2). Potential environmental, social and economic effects are discussed below.

a) Development Control

The municipalities could control future development of unsubdivided flood plain land to ensure that new flood plain development is compatable with the flood hazard. This could be accomplished by adopting a flood plain development policy to disallow further flood plain development,

Table 6.2

GENERAL EFFECTS OF SELECTED ALTERNATIVE LAND USE POLICIES: VACANT UNDEVELOPED LAND

Alternative	Purpose	Effects		
		Environmental	Social	Economic
development control	-to maintain flood plain free of development	-retain riverside park land/open space/wild-life habitat	-opposition to control by landowners -flood plain community growth restricted	-lost opportunity cost to speculators -potential flood damages will not increase
public purchase	-to ensure flood plain is not developed -compensate property owners	-retain riverside park land/open space/wild-life habitat	-opposition to purchase by property owners -flood plain community growth restricted	-land purchase could be expensive -lost opportunity cost to speculators -potential flood damages will not increase

rather than to "discourage" development, as does the City of Drumheller and I.D. No. 7 present policy. Or, a caveat could be placed on vacant flood plain by the land owner to prevent future development that is not compatable with the flood hazard. This type of policy would facilitate implementation of recommendation 31 of the General Plan, to create a riverside parkland belt along the Red Deer River, by ensuring no future subdivision and development of the flood plain occurs. New community growth would be directed away from the flood plain, and future growth of existing flood plain communities onto the flood plain would be restricted. Opposition to this type of policy could be anticipated from property owners, particularly those who would lose anticipated speculation profits. Nevertheless, bearing these effects in mind, this alternative would ensure that potential flood damages on presently undeveloped land do not increase substantially.

b) Public Purchase

If undeveloped flood plain land is purchased by either the municipal or provincial government, the flood plain would not be further subdivided or developed, and property owners would be compensated, although perhaps not for their entire loss, particularly if speculative profits were anticipated. This alternative would ensure that presently undeveloped flood plain land is maintained as parkland and open space, as is recommended in the General Plan. Like development control, flood plain purchase would restrict future community growth on the flood plain. Opposition could be anticipated from landowners. As has been shown in other Alberta situations, such as the Oldman and Red Deer dam public hearings, the cost for purchase or expropriation of property would be

high. This would probably be true in the Drumheller Valley, since flooding has not occurred for 25 years and public awareness of the hazard is probably low. Indeed, if public purchase is considered as an alternative adjustment, it may be worthwhile considering gradually purchasing flood plain properties, at market value, as they become available, rather than trying to purchase all of the flood plain at one time. This also has merit, in that remaining lands would be more clearly identified as being on the flood plain. Moreover, if a two-zone flood plain is adopted, public purchase of the inner zone would reduce the flood hazard with less public opposition. Development could be allowed with flood proofing on the floodway fringe.

6.3.2 New Subdivision Applications for Undeveloped Land

The PRPC controls, to some degree, new subdivision and development of flood plain land by approving subdivisions with contingent development agreements and by requiring environmental reserve from new subdivisions along the river edge. Several alternatives to the existing policy for subdivision approval and environmental reserve requirements are suggested (Table 6.3). Potential environmental, social and economic effects of each alternative policy are discussed below.

a) Approval/Development Agreement

Subdivision of the 1:100 year flood plain is allowed with flood proofing to the satisfaction of relevant authorities by the PRPC. This policy permits new subdivision of flood plain land but, through a development agreement, the PRPC ensures that new development is flood proofed. Thus, potential flood damages are not increased significantly

Table 6.3

GENERAL EFFECTS OF SELECTED ALTERNATIVE LAND USE POLICIES: NEW SUBDIVISION APPLICATIONS

Alternative	Purpose	Effects		
		Environmental	Social	Economic
approval/ development agreement				
i) allow on 1:100 year flood plain with flood proofing	-allow new subdivision -ensure that new buildings are flood proofed	-flood plain not retained as open space -new development may obstruct flood flows	-opposition from developers -new and existing communities will grow on flood plain	-high development costs -low flood damage costs
ii) allow on floodway fringe with flood proofing	-owner retains floodway -limited subdivision -new buildings are flood proofed	-floodway retained as open space -flood flows not obstructed	-opposition from developers -new and existing communities will grow on floodway fringe	-high development costs -low flood damage costs
iii) allow on floodway fringe without flood proofing	-allow new subdivision of flood plain	-flood plain not retained as open space -flood flows may be obstructed	-flood plain communities would grow	-average development costs -high flood damage costs
iv) disallow on 1:100 year flood plain	-ensure that new subdivision is not on the flood plain	-retain riverside open space/parkland/ agriculture -flood flows not obstructed	-opposition from land owners -community growth restricted	-flood damage costs will not increase

Table 6.3-Continued

Alternative	Purpose	Effects		
		Environmental	Social	Economic
Environmental Reserve				
i) require designated width	-decrease potential flood damage along river -allow floodplain development	-buffer zone retained as open space -new development could obstruct floodway -width not constant in terms of flood frequency	-minimal developer opposition -flood plain communities would grow	-development costs increased slightly -potential flood damages may increase somewhat
ii) require designated floodway	-decrease potential flood damages -public ownership of floodway -allow limited subdivision	-floodway retained as parkland/open space -new development will obstruct flood flows	-opposition from developers -new and existing communities will grow on fringe areas	-if owner not compensated high development costs -if purchased by government, public cost would be high
iii) require 1:100 year flood plain	-ensure no further development of flood plain -public ownership	-retain riverside parkland/open space/agriculture -flood flows not obstructed	-opposition from land owners -community growth restricted	-lost opportunity cost to land owner, if not compensated -if compensated by government, public cost would be high

If it is anticipated by the PRPC or its advisor the Alberta Department of the Environment that a proposed development would cause backwater flooding, it would likely be refused. This approach does not ensure a buffer of open space along the riverside, although in most cases, it has this effect. Opposition to flood proofing or raising the land with fill can be anticipated from subdivision applicants and developers as a result of increased construction costs. However, once the land is developed with flood proofing, potential damages to the design flood level will be minimal. Flood damages would occur if the design flood is exceeded or if backwater flooding is caused. This policy would allow new and existing communities to grow on the flood plain.[4]

If subdivision is allowed on the floodway fringe with flood proofing a designated floodway would remain unobstructed to carry peak flows and new development on the fringe would be protected to the 1:100 year flood level. This policy differs from the policy discussed in the preceding paragraph because the floodway zone, where development is not allowed, would be designated and the subdivision applicant would be aware of its location before making a subdivision application. Under the present

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[4]The economic viability of flood proofing in the Drumheller Valley warrants careful investigation. Although new flood plain development is to be flood proofed, there have been no economic studies of flood proofing in Alberta. As noted in chapter three (section 3.2.4), it was found to be economically justified for low density, urban development experiencing frequent flooding. It was found to be most desirable for commercial developments and least desirable for residential developments. Facts, such as these, should be carefully studied before flood proofed development on the flood plain is allowed to continue as part of a Drumheller flood plain management policy.

the applicant submits his subdivision plans for the flood plain and subdivision and development are refused for the area where backwater flooding would be caused. Using a designated floodway fringe, potential purchasers and subdivision applicants would be aware of the floodway location prior to a costly investment. If new flood plain subdivision is restricted to the floodway fringe, with a development agreement for flood proofing, the flood plain would be retained as open space or park-land, and future flood damage costs would not be increased. New and existing communities would be able to grow on the floodway fringe. This policy would likely be opposed by developers who could not subdivide floodway property and would face higher development costs as a result of flood proofing.

Subdivision of the 1:100 year flood plain without flood proofing is unlikely in light of current PRPC policy. But, it could occur if a PRPC decision to disallow subdivision or to require flood proofing of new development is reversed by an Appeal Board decision. If the flood plain is subdivided and developed, flood flows would be obstructed and backwater flooding would occur. In addition, the new development would be vulnerable to damages in the event of a flood. This policy has the social advantage that flood plain communities would continue to grow unhampered. However, in the event of a major flood, social and economic disruption would occur. If provincial government compensation is provided by Alberta Disaster Services to flood victims, much of the financial cost of flood plain occupance would be transferred to society as a whole. Indeed, potential losses and the cost to society would increase with each new subdivision allowed on the flood plain without flood proofing.

If subdivision is disallowed on the 1:100 year flood plain, the entire flood plain would be maintained for open space, parkland or agricultural uses in rural areas. This policy would ensure that potential flood damages will not increase in presently unsubdivided areas of the flood plain. However, opposition could be anticipated, not only from flood plain landowners, but also from Drumheller Valley residents, since development is, for the most part, restricted to the valley floor, much of which is flood plain (CRPC 1978).

b) Environmental Reserve

When approving a subdivision adjacent to a water body, the PRPC must require the applicant to provide a 20-foot (6.1 m) wide environmental reserve along the water shore, without payment. Moreover, as discussed in the previous chapter, the PRPC may request that land "subject to flooding" be provided, without payment, as environmental reserve, to be used as parkland or open space by the municipality (Planning Act 1977, section 107). If a wide environmental reserve is required by the PRPC for flood protection, compensation to the property owner would ease opposition somewhat.

The PRPC policy is to require a designated width of environmental reserve. The width varies, both in terms of distance and flood frequency level, from one subdivision application to the next, although it is frequently based on the recommendation of the Alberta Department of the Environment with respect to backwater flooding. Two alternative policies are suggested in this section: require a designated floodway as environmental reserve and require the 1:100 year flood plain as environmental reserve.

A designated width of environmental reserve along the river edge is required from each new subdivision by the PRPC. The width generally exceeds the required 6.1 m, but it is not standard. Frequently, it is based on the backwater computations prepared by the Alberta Department of the Environment. This policy decreases potential flood damages adjacent to the river since a buffer zone of at least 6 m is maintained. However, since the width is not standard, decisions may be made on an ad hoc basis, and may become based on precedent, rather than the flood hazard, over time. Developer opposition and potential flood damages would depend, to a large degree, on the width of environmental reserve required. The buffer zone would protect new development from high frequency floods; however, depending upon the set-back requirement and flood proofing of buildings, low-frequency floods could potentially cause damage to development beyond the buffer zone.

If a designated floodway, based on a defined flood frequency, is required as environmental reserve, development in the floodway would be prevented and the municipality would gain land for the park along the Red Deer River that was proposed in the General Plan. Depending upon the width of the floodway and the size of the proposed subdivision, owner opposition to donating this land could be anticipated. However, the municipal or provincial government could consider a policy to compensate subdivision applicants for environmental reserve in excess of the 6.1 m minimum requirement, to ease developer opposition.

The entire 1:100 year flood plain could be required without payment by the PRPC as environmental reserve, if it is considered to be "subject to flooding". Even if the developer is offered a payment, opposition could be anticipated, not only from flood plain subdivision applicants,

but also from Drumheller Valley residents, as discussed under "approval/ development agreement", above. This policy would ensure that the undeveloped flood plain in the Drumheller Valley is maintained for parkland, open space and agricultural uses.

6.3.3 Vacant Subdivided Lots

Two mechanisms for managing vacant subdivided land are suggested: development control and public purchase (Table 6.4). Potential environmental, social and economic effects of alternative policies for each are discussed below.

a) Development Control

Single family residences on subdivided lots are deemed approved in appropriate land use districts in the City of Drumheller (1976, section 2.2.1). That is, no development permit is required, even on the flood plain. In the City of Drumheller, particularly Newcastle and Midlandvale, thirty percent of the buildings have been built during the past decade. The majority of these have been constructed on existing vacant lots or lots where an old building has been removed. In the City of Drumheller, most of the original dwellings were built quickly during the coal boom. These are now being replaced by more substantial dwellings, but on the same lots. This is discussed more fully in chapter seven. The policy of deemed approved development does not allow the City to control new developments in existing subdivisions that are on the flood plain, for example in Midlandvale and Newcastle. This policy allows flood plain communities to grow unhampered with average development costs on subdivided land. However, with each new building that

Table 6.4

GENERAL EFFECTS OF SELECTED ALTERNATIVE LAND USE POLICIES: VACANT SUBDIVIDED LOTS

Alternative	Purpose	Effects		
		Environmental	Social	Economic
development approval				
i) allow deemed approved development	-to keep development costs low -to allow community growth	-single family dwellings can be built on the flood plain -open space is not maintained -flood flows may be obstructed	-communities may grow unobstructed	-average development costs -potential 1:100 year flood damages will increase
ii) allow on 1:100 year flood plain with flood proofing	-to allow new development -to ensure it is flood proofed	-flood plain is not maintained as open space -flood flows may be obstructed	-opposition from developers -new and existing communities will grow on the flood plain	-high development costs -potential flood damage from 1:100 year flood will not increase
iii) allow on floodway fringe with flood proofing	-to allow some flood plain development -to ensure it is flood proofed	-existing floodway open space would be maintained	-opposition from floodway property owners -existing floodway communities may deteriorate	-high development costs -floodway property values may decline -potential flood damages will decrease slowly

Table 6.4-Continued

Alternative	Purpose	Effects		
		Environmental	Social	Economic
iv) disallow on 1:100 year flood plain	-to ensure that new development is not on the flood plain	-existing flood plain open space would be maintained	-opposition from flood plain property owners -flood plain communities may deteriorate	-flood plain property values may decrease -potential flood damages will not increase and may decrease
public purchase	-to prevent future development of vacant lots	-existing flood plain open space would be maintained	-opposition from property owners who intend to develop -flood plain communities may deteriorate	-flood plain property values may decline -potential flood damage will not increase and may decrease

is constructed on the flood plain without flood proofing, potential flood damages increase to the building itself and to upstream development from backwater flooding. If this policy is changed, opposition could be anticipated from flood plain developers and landowners. However, as discussed below, a development bylaw requiring flood proofing of new structures would gradually reduce potential flood damages as old houses are replaced with new flood proofed dwellings.

Development is allowed on the 1:100 year flood plain with flood proofing in I.D. No. 7. There is no flood proofing requirement in the City of Drumheller. If new subdivision is not involved, neither the City nor I.D. No. 7 has to send the development application to the PRPC or the Alberta Department of the Environment for comment. This policy allows existing and new communities to grow on the flood plain, but ensures that buildings in I.D. No. 7 are protected to the design level of flood proofing. It does not promote gradual development of the riverside parkland system, as recommended in the General Plan.

If new development of subdivided lots is allowed only on the floodway fringe with flood proofing, the floodway would not be obstructed further. These undeveloped lots could gradually be acquired for riverside parkland as they become available. This would probably result in a gradual decrease in potential flood damages. This type of policy would be possible in some communities, such as Nacmine, Rosedale (excluding the Aerial flats) and Drumheller proper, where there are very few developed, subdivided lots on the 1:25 year flood plain, an approximate floodway. However, in other cases, such as Midlandvale, this type of policy would probably cause a gradual decline of much of the community which is on the flood plain. Some opposition could be anticipated from

flood plain property owners, depending upon how much of the community would be affected.

If new development of subdivided lots is not allowed on the 1:100 year flood plain, existing open space on the flood plain would be maintained and would gradually increase, as old dwellings are vacanted. Potential flood damages would gradually decrease if new homes are not built in their place. Opposition could be anticipated from flood plain developers and property owners, particularly in communities such as Midlandvale, North Drumheller and Cambria, since most of these communities are located predominantly on the 1:100 year flood plain.

b) Public Purchase

If vacant, subdivided lots are purchased by either the municipality or the provincial government, future development of the flood plain would be prevented, the owner would be compensated, at least in part, and future flood damages may gradually decrease. This alternative would be most viable in communities such as East Coulee and Nacmine, where there is a high proportion of vacant, subdivided lots on the flood plain or in Drumheller, where a high proportion of the flood plain is already owned by the City and used for recreation. Less opposition would probably arise if the properties are purchased, at market value, as they come up for sale, or if such a program is initiated following a flood event.

6.3.4 Developed Subdivided Lots

Four policies for managing developed subdivided lots are suggested: leave unprotected, flood proofing enforcement, protection and public

purchase (Table 6.5). Potential environmental, social and economic effects of the alternative policies are discussed below.

a) Leave Unprotected

At present, most buildings in the Drumheller Valley are not protected from flooding. However, there are several exceptions, such as the dyke at East Coulee and some flood proofed buildings. City of Drumheller officials estimated that ten percent of existing flood plain development was flood proofed in 1977 (James F. MacLaren Limited 1978, p.c-28). During the field work, some buildings were observed to be flood proofed, particularly in North Drumheller. However, none were protected beyond the 1:25 year flood level. If existing development is left unprotected, there would be no cost for protection; however, social and economic disruption would occur in the event of a major flood.

b) Flood Proofing

If owners are required to pay for flood proofing existing buildings, they would be protected, to some degree, from flooding, the owner would be aware of the hazard and would also be responsible for the cost of protecting his property. Owner opposition to flood proofing could be anticipated since it would result in structural changes, renovation costs and associated inconvenience during renovations.

If the municipality paid the entire cost of flood proofing existing buildings, they would be protected to some degree, from the flood hazard. However, the flood plain occupant would not be responsible for the costs of his choice to locate on the flood plain, since the costs of protection

Table 6.5

GENERAL EFFECTS OF SELECTED ALTERNATIVE LAND USE POLICIES: DEVELOPED SUBDIVIDED LOTS

Alternative	Purpose	Effects		
		Environmental	Social	Economic
leave unprotected	-flood proofing at individual iniative -maintain present situation	-	-little opposition -social disruption in the event of a flood	-no present cost -high cost if flooding occurs
enforce flood proofing				
i) owner pays	-occupant responsible for reducing flood damages	-	-owner opposition to outside enforcement, disruption, change	-high cost to owner -potential flood damage cost reduced
ii) municipality pays	-flood proofing costs paid by all municipal property owners	-	-owner opposition to outside enforcement, disruption, change	-possible tax increase -potential flood damage cost reduced
iii) province pays	-flood proofing costs paid by all citizens of Alberta	-	-owner opposition to outside enforcement, disruption, change	-possible tax increase -potential flood damage cost reduced
iv) cost sharing	-occupant responsible for part of the costs	-	-owner opposition to outside enforcement, disruption, change	-cost spread between flood plain occupant and society -potential flood damage costs reduced

Table 6.5-Continued

Alternative	Purpose	Effects		
		Environmental	Social	Economic
protection	-to provide protection to existing development	-loss of existing open space/wildlife habitat along river edge where dykes are constructed	-opposition from property owners: property loss, loss of view, declining property values	-costs paid by provincial government -flood damage costs reduced to design flood level -high flood damage costs if dykes are overtopped
public purchase	-to eliminate potential flood damage	-riverside parkland/ open space increased -flood flows not obstructed	-social disruption caused by community relocation -opposition from property owners	-low future flood damage costs -very costly to funding agency and to flood plain residents

would be spread to all municipal property owners. This could result in increased municipal taxes. Owner opposition could be anticipated as a result of structural changes and associated inconvenience.

If the provincial government paid the flood proofing costs, the cost would be shifted to all taxpayers of the province. It could result in increased provincial taxes, if offered to all flood plain communities in Alberta. This type of policy would probably not result in decreased flood plain occupance, because the costs would not be paid by flood plain occupants. Some owner opposition could be anticipated as a result of structural changes and associated inconvenience.

Flood proofing costs could be shared among the province, municipality and the property owner. In this way, the owner would be responsible for part of the cost of his flood plain occupance and potential flood damages would be reduced. Again, owner opposition could be anticipated due to inconvenience, structural changes and associated costs.

c) Protection

Existing flood plain development can be protected by structural measures. As discussed in chapter four, the Alberta Department of the Environment is planning to construct a reservoir 240 km upstream of the Drumheller Valley. With sufficient warning, it was anticipated in a preliminary study, that the Red Deer Dam would reduce potential flood damages from a 1:100 year flood in urban areas of the Drumheller Valley by as much as forty percent (Klohn Leonoff Consultants Limited 1977). The Alberta Department of the Environment, Planning Division is investigating the possibility of protecting existing flood plain development with dykes as part of the Drumheller Flood Control Study. If

protective measures are constructed, they will greatly influence future flood plain land management decisions in the protected area.

Depending upon the dyke location, existing open space and wildlife habitat along the river edge may be reduced. Opposition from land owners can be anticipated from those who will lose property as a result of dyke construction, those whose river view will be obstructed by the dykes, those whose property values will be reduced and those who do not believe that a flood hazard exists. Unless strict development policies are adopted by the municipality, development behind the dykes will probably increase, as these structures generally give landowners a false sense of security (White et al. 1958). If a flood exceeds the design level of the dykes, the resultant damages may be greater than if the dykes had not been built.

d) Public Purchase

Developed flood plain could be purchased by the municipality or the Alberta Department of the Environment, under the Municipal Government Act, the Water Resources Act and the Department of Environment Act, as discussed above. Past experience with public purchase and expropriation of land in Alberta suggests that public opposition could be anticipated, particularly in the City of Drumheller, where a large portion of some communities, such as Midlandvale and North Drumheller, would be involved. Public purchase would probably meet less opposition if properties are purchased gradually, as they come up for sale. If a damaging flood occurs, public purchase may be facilitated in developed areas; people may evacuate the flood plain voluntarily or may be persuaded to move, if government compensation to move, rather rebuild

in the same location, is an added incentive (Mitchell et al. 1978).

6.3.5 Lots Containing Abandoned Buildings

Two policies for managing lots containing abandoned, dilapidated buildings are suggested: require removal and public purchase (Table 6.6). Potential environmental, social and economic effects of these policies are discussed below.

a) Require Removal

The Minister of Municipal Affairs may require an owner to remove dilapidated buildings, without compensation and without purchasing the land, in I.D. No. 7 (Improvement Districts Act 1970, section 29). This includes buildings in existing subdivisions or on unsubdivided land, such as squatters' dwellings. In the hamlets, particularly East Coulee, there is a significant proportion of unoccupied, dilapidated buildings; their removal would reduce potential flood damages, prevent new occupants from moving in and up-grading the buildings without flood proofing and provide open space on the flood plain.

b) Public Purchase

Abandoned buildings and associated property could be purchased by the municipality or by the Alberta Department of the Environment under the legislation discussed above. Provided the abandoned buildings are removed, additional land would be made available for parkland or open space on the flood plain. Implementation of this policy would reduce potential flood damages; costs would spread to society as a whole.

Table 6.6

GENERAL EFFECTS OF SELECTED LAND USE POLICIES: ABANDONED BUILDINGS

Alternative	Purpose	Effects		
		Environmental	Social	Economic
require removal	-to reduce potential flood damages -owner pays	-improve community appearance -increase open space on flood plain -reduce potential flood hazard	-	-cost paid by owner -reduce flood damage costs
public purchase	-reduce potential flood damages -increase public ownership of flood plain	-improve community appearance -increase open space on flood plain -reduce potential flood hazard	-	-cost paid by public -reduce flood damage costs

6.4 The Role of Land Use Zoning

Once the municipalities, the PRPC and the Alberta Department of the Environment adopt land use management policies for flood plain land in the Drumheller Valley, specific ways of implementing these policies, through subdivision approval and development control, can be evaluated and adopted.

The municipalities manage development through the development control bylaw. In order to control flood plain development, the municipalities may either adopt general flood plain development policies or may create special flood plain land use districts and designate development criteria for each district (Planning Act 1977, section 67). Both the City of Drumheller and I.D. No. 7 have chosen to adopt general flood plain development policies.

If special flood plain land use districts are adopted, they would be defined in the development control bylaw. Examples of possible flood plain land use districts are:

-open space/recreation

-flood proofed residential (single family, two family, multi family)

-flood proofed commercial

-flood proofed light industrial

-flood proofed general industrial.

In a possible open space/recreation district, only development for recreational uses would be allowed. In the districts requiring flood proofing, guidelines pertaining to the type of flood proofing, type of structure and maximum depth of fill allowed would be specified. Guidelines would also be set out for existing development on the flood plain.

Presently, in the City of Drumheller, Direct Control Districts are used by the municipality to control new development for some areas of the flood plain, for example parts of North Drumheller and Newcastle (appendices C and D). However, new development has been allowed on the flood plain, in these districts, without flood proofing in recent years. These districts could be used more effectively to ensure that new development is compatable with the degree of flood hazard.

The two municipalities use different philosophies for the creation of land use districts. In I.D. No. 7, there are only three categories of land use: hamlet residential districts, hamlet commercial districts and conservation-agricultural districts. To add a varity of flood-compatible land use districts, such as flood-proofed hamlet residential, may not be compatible with the improvement district management philosophy. In the City of Drumheller, there is a wide variety of land use types. Creating flood-compatible land use districts may be more feasible in the City. However, this would have to be approached cautiously, because public opposition to "down zoning" and the associated decline in property values would probably occur (Fenwick 1979c).

It has been suggested (White 1979) that municipal land use districts should be made flexible on the flood plain, so that following a flood, the municipality would have the freedom to rezone property to flood-compatable uses when flood plain occupants are aware of the flood hazard and may be willing to relocate. Then, compensation to flood victims, from Alberta Disaster Services, should be provided to allow flood victims to relocate, rather than rebuild on the flood plain.

6.5 Discussion

In this chapter, alternative land use policies have been suggested and discussed for undeveloped and developed land in the Drumheller Valley. It is clear that virtually any policy to control or limit the use of private flood plain land will be met with a degree of owner opposition, particularly because there have been no damaging floods in the Drumheller Valley for the past 25 years. Nevertheless, the potential savings from reducing future flood damages by diverting new development away from the flood plain, in conjunction with the social, aesthetic and environmental effects of creating a riverside parkland system should be thoroughly considered and evaluated. Thus, in the following chapter, potential effects of each of these alternative policies are discussed for each of the ten Drumheller Valley communities.

CHAPTER VII

ALTERNATIVE LAND USE POLICIES FOR DRUMHELLER VALLEY COMMUNITIES

7.1 Introduction

In this chapter, the land use and building characteristics of each Drumheller Valley community are described, based on the survey conducted in 1978. Potential environmental, social and economic effects of adopting the alternative land use policies outlined in chapter six are discussed for undeveloped vacant land, new subdivision applications, vacant subdivided lots, developed subdivided lots and abandoned buildings. General land use policies are recommended for each community, bearing in mind that it is not generally economical to prohibit all new development of the flood plain. Flood damages should be minimized while significant use of the flood plain should be retained. The four City of Drumheller communities are considered first, the I.D. No. 7 hamlets are considered second, and the rural community is considered third.

The land use policies recommended for each community reflect four general goals[1] defined by the author for flood plain management in the Drumheller Valley: first to maximize utilization of the flood plain that will not be adversely affected by flooding (such as parkland, recreation, agriculture, storage, parking lots and flood proofed development); second, to minimize disruption to existing communities; third,

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[1] These types of goals had not, at the time of writing of this thesis, been prepared by the Alberta Department of the Environment, the PRPC or either municipality as part of the Drumheller Flood Control Study.

to minimize the cost of protective works and to share the cost of protection between the government and new and existing flood plain occupants; and fourth, to use the environmental reserve to ensure that new subdivisions provide a floodway, free of intensive development, to carry flood flows.

Throughout the following discussion, it should be noted that the population of the Drumheller Valley is growing at a rate well below that of the province of Alberta. In fact, between 1974 and 1978, the provincial population grew at an average annual rate of 3.5%, whereas the City of Drumheller population grew at an average annual rate of 1.3% and the I.D. No. 7 population increased by less than one percent per annum[2] (Alberta, Department of Municipal Affairs 1978, pp. 1,6,7). In the CRPC background study for the Drumheller Valley General Plan, planning recommendations were based on a five percent average annual growth rate, starting in 1975 (1978, p.1-10). This appears to unrealistically high, since it would result in a doubling of the Drumheller Valley population to 15,000 people by 1990. Unless there is a sudden impetus for population growth, this target will not be reached. According to the CRPC projection, the 1978 population of the Valley should have been 8,269 people; in fact, it was 7,464. This is even below the population figure of 7,500 people used by the CRPC as the base population for 1975. Thus, although growth and new development are discussed in this chapter, it should be remembered that the population is growing slowly.

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[2] I.D. No. 7 population statistics were not recorded between 1971 and 1974 and for 1978; the statistics for 1975 and 1977 indicate an overall increase of about one percent.

However, the number of new buildings on the Drumheller Valley flood plain appears to be growing more rapidly than the population, at a rate of three percent per annum in recent years. Conversations with local residents during the field study indicated that many existing residents are constructing new buildings, particularly dwellings, to replace old structures that have deteriorated. Thus, much of the new development is occuring to meet the needs of Drumheller Valley residents.

7.2 Drumheller Valley Land Use

In 1978, there were 783 buildings on the Drumheller Valley 1:100 year flood plain. Sixty-eight percent of these were in the City of Drumheller. Newcastle had the highest number (172), followed by Midlandvale (148), North Drumheller (116) and Drumheller (94) (Figure 7.1). In these four communities, there was more development between the river edge and the 1:25 year flood line than between the 1:25 and 1:50 and 1:50 and 1:100 year flood lines. Twenty-nine percent of the Drumheller Valley flood plain buildings were in the hamlet communities. When compared to the other hamlets, Rosedale had the most flood plain buildings because the Aerial flats were included with Rosedale. In East Coulee, 62 buildings were located on the 1:100 year flood plain, including two houses in the squatter community of Western Monarch.[3] There were 48 buildings on the Nacmine 1:100 year flood plain. In Cambria, there were 27 and

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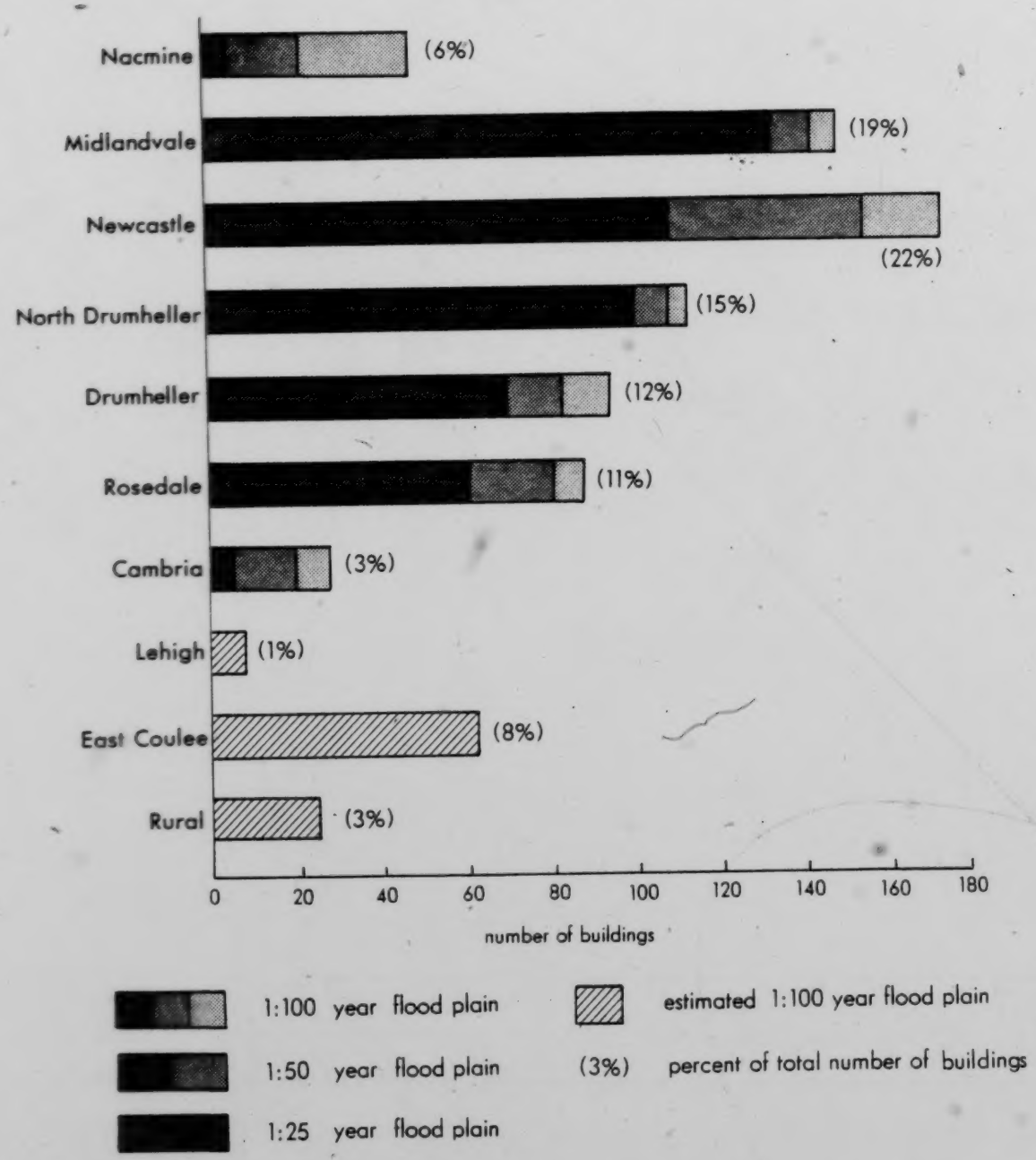
[3]As discussed in chapter two (section 2.4), at the time of the thesis research, the flood plain maps which were being prepared by Klohn Leonoff Consultants Limited had not been completed for the flood plain south of Cambria. Thus, the 1:100 year flood plain boundary was estimated by the author for this area.

Figure 7.1

TOTAL NUMBER OF FLOODPLAIN BUILDINGS BY COMMUNITY [a)]



a) includes occupied and unoccupied buildings

in Lehigh there were 7 buildings on the flood plain. In Nacmine and Cambria, only a small proportion of the development was on the 1:25 year flood plain. Three percent of the Drumheller Valley flood plain development was rural.

In the Drumheller Valley, there were numerous abandoned buildings; however, at the same time, new homes were being built. Midlandvale and Newcastle seemed to be attracting the most growth, since fifty-eight percent of the homes built during the past decade on the Drumheller Valley flood plain have been built in these two communities. In the hamlets and rural areas, new homes were in evidence, even in Lehigh which had no services and a high proportion of abandoned dwellings. As noted above, most of this development has occurred to meet the needs of existing Drumheller Valley residents.

Drumheller Valley flood plain land use was predominantly residential (Table 7.1). In fact, 83% of the flood plain buildings were single family residential. An additional 10% were squatters, living in single family dwellings. Only 3% of the flood plain buildings were commercial and 1% were used for light industrial or storage purposes.

The majority (545) of the 1:100 year flood plain buildings were built prior to 1940. Some had been renovated recently; 12% were unoccupied. Approximately 161 flood plain buildings have been constructed since 1970; 7% of these were unoccupied. The remaining 1% were built between 1940 and 1970.

According to the Alberta Department of Municipal Affairs classification, which was described in chapter two (section 2.5), only 3 buildings (1%) were class B. One of these was unoccupied because it was under construction. One hundred and sixty (20%) were class C; eight of

Table 7.1

DRUMHELLER VALLEY: LAND USE AND BUILDING DESCRIPTION

Variable	occupied buildings	unoccupied buildings	total buildings (number)	(percent)
Land Use[a]				
single family residential	593	58	651	83%
two family residential	7	6	13	2%
multi family residential	1	0	1	0%
squatter	67	9	76	10%
commercial	21	0	21	3%
industrial/storage	9	0	9	1%
hotel	4	0	4	1%
public	5	3	8	1%
Building Age[b]				
pre-1940	481	64	545	69%
1940-1949	18	0	18	3%
1950-1959	29	1	30	4%
1960-1969	29	0	29	4%
post 1970	150	11	161	20%
Building Class[b]				
B	3	1	4	1%
C	128	8	136	17%
D	158	2	160	20%
E	140	32	172	22%
F	218	32	250	32%
mobile	57	1	58	7%
quonset	3	0	3	1%
Building Condition[a]				
good	207	12	219	28%
fair to good	122	0	122	16%
fair	194	10	204	26%
fair to poor	75	4	79	10%
poor	109	50	159	20%
Lowest Water Entry Point[a]				
First Floor Only				
0-0.5 meter	350	54	404	52%
0.6-1.0 meter	49	5	54	7%
+1.0 meter	3	0	3	1%
Basement/First Floor				
0-0.5/0-0.5 meter	62	1	63	8%
0-0.5/0.6-1.0 meter	216	14	230	29%
0-0.5/+1.0 meter	27	2	29	3%

Source: a) Field Survey, conducted by the author, September, 1978.
b) Municipal Tax Assessment Forms, August, 1978.

Note: The criteria for each variable are discussed in chapter two (2.5).

these were unoccupied. One hundred and seventy (22%) were class E; 32 of these were unoccupied. The majority, 250 (32%) were class F; 32 of these were unoccupied. In addition, there were 58 mobile or modular homes and three quonsets. The majority of buildings were in good (28%) or fair (26%) condition.

Each of the ten Drumheller Valley communities had different land use and building characteristics. Before discussing these, several broad generalities should be noted. First, the urban flood plain, particularly below the 1:25 year flood line, is more intensely developed in the City of Drumheller communities than in the hamlets. In fact, in several hamlets, subdivision of the 1:25 year flood plain appears to have been avoided. Second, most of the recent development in the Drumheller Valley has been concentrated in Newcastle and Midlandvale, although all communities have seen some new development in the past decade. Third, many of the new dwellings tended to be modular and mobile homes, especially in the hamlets. Finally, water and sanitary sewer services existed from Nacmine to Rosedale in 1978. Gas service extended from Nacmine to Cambria. Beyond Cambria, water was drawn from wells; septic tanks were used for disposal and most dwellings were heated with propane. Some homes were heated by wood stoves, especially in East Coulee.

7.3 Midlandvale

7.3.1 Land Use

In Midlandvale, 148 buildings were located on the 1:100 year flood plain in 1978 (appendix C). Ninety-four percent of these were also on the 1:50 year flood plain and 89% were on the 1:25 year flood plain.

On the 1:100 year flood plain, there were 144 single family dwellings, one general store and three abandoned school houses (Table 7.2). Ninety-two buildings (62%) were built prior to 1940; nine of these (6%) were unoccupied. Forty-two buildings (28%) have been built since 1970; two of these (1%) were unoccupied because they were under construction. The remaining 10% were built between 1940 and 1970; none of these were unoccupied.

According to the Alberta Department of Municipal Affairs classification, 28 buildings were class C and 28 were class D. Two class C dwellings were under construction. Twenty-four dwellings were class E, and 6 of these (25%) were unoccupied. The majority of homes (48) were class F and one percent of these was unoccupied. Finally, 18 mobile or modular homes were located in Midlandvale; for the most part, these were located in the eastern part of the community (appendix C). The majority of flood plain buildings were in good condition; only 10% were in poor condition.

Forty percent of the buildings had a basement water entry point. The majority of these (39) had a basement opening less than 0.5 m above the ground and a first floor 0.6 to 1.0 m above the ground. Seventy percent of the buildings (87) had no basement water entry point; the majority of these (80) had first floors less than 0.5 m above ground level.

The majority of Midlandvale was zoned for single family residential uses (appendix C). The east-central portion was zoned as mobile home residential. Two land parcels in the eastern portion of Midlandvale were zoned as agricultural and single family residential districts. These were being prepared for subdivision in 1978.

Table 7.2

MIDLANDVALE: LAND USE AND BUILDING DESCRIPTION

Variable	occupied buildings	unoccupied buildings	total buildings (number)	(percent)
Land Use[a]				
single family residential	136	8	144	97%
commercial	1	0	1	1%
public	0	3	3	2%
Building Age[b]				
pre-1940	83	9	72	62%
1940-1949	3	0	3	2%
1950-1959	3	0	3	2%
1960-1969	8	0	8	5%
post 1970	40	2	42	28%
Building Class[b]				
C	28	2	30	20%
D	28	0	28	19%
E	18	6	24	16%
F	45	3	48	32%
mobile	18	0	18	12%
Building Condition[a]				
good	46	2	48	32%
fair to good	21	0	21	14%
fair	33	5	38	26%
fair to poor	23	0	23	16%
poor	14	4	18	12%
Lowest Water Entry Point[a]				
First Floor Only				
0-0.5 meter	58	5	63	54%
0.6-1.0 meter	21	3	24	16%
Basement/First Floor				
0-0.5/0-0.5 meter	14	0	14	9%
0-0.5/0.6-1.0 meter	36	3	39	26%
0-0.5/+1.0 meter	8	0	8	5%

Source: a) Field Survey, conducted by the author, September, 1978.
b) Municipal Tax Assessment Forms, August, 1978.

Note: The criteria for each variable are discussed in chapter two (section 2.5).

7.3.2 Alternative Land Use Policies

a) Vacant Undeveloped Land

In 1978, there was little undeveloped flood plain land in Midlandvale which could be considered for public purchase. Between the three houses east of Midlandvale and the Red Deer River (appendix C), the land was open space and zoned for agricultural use. The City or the province may be able to purchase, or control use of this land if a riverside parkland scheme is adopted. Alternatively, the City could restrict future development using the development control bylaw. The effects would depend upon the owner's intention for future use of this property.

b) New Subdivision Applications

The PRPC is against allowing 1:100 year flood plain subdivision without flood proofing. Thus, the new subdivision in eastern Midlandvale has been allowed, with a development agreement for flood proofing. Under the present policy, the undeveloped land east of this subdivision could be developed with fill, if backwater flooding would not be caused (appendix C). If further subdivision of the 1:100 or 1:25 year flood plains is not allowed, future subdivision and development of Midlandvale would have to occur on the north side of the highway.

Under the existing policy, a designated width of environmental reserve has been required by the PRPC from the new subdivision. This will decrease potential damages to new development from high frequency floods. The effects from a major event will depend upon the depth of fill and the flood stage. If either the 1:25 or 1:100 year flood plain is required as environmental reserve, in future, this would involve most of the land available for subdivision between the Dinasour Trail and the

Red Deer River in Midlandvale. Subdivision would be limited to the R-1 area outside of the flood plain and to the land north of the Dinasour Trail (appendix C).

c) Vacant Subdivided Lots

There were approximately 24 lots on the Midlandvale flood plain which could be developed for single family dwellings without a development permit (20 vacant lots and 4 unoccupied, poor condition dwellings). This does not include the new subdivision approved with flood proofing in eastern Midlandvale. All were on both the 1:25 and 1:100 year flood plain; almost half were at the river edge (appendix C). If development occurred without flood proofing, potential flood damages would increase. If new development is only allowed on the floodway fringe, with flood proofing, none of these lots could be developed because they are on the 1:25 year flood plain. If development of the entire flood plain is allowed with flood proofing, the lots could be developed and the flood damage potential would increase very little, depending upon associated adjustments, such as flood warning and emergency preparedness. However, the land fill could cause backwater flooding. Also, a maximum allowable depth of fill would have to be specified to prevent new buildings from being raised an unsightly height above surrounding development.

d) Developed Subdivided Lots

About 85% of existing development had a water entry point less than 0.5 m above the ground. In the event of a 1:100 year flood, the entire Midlandvale flood plain would be inundated to a depth of 0.5 to 2.5 m. Thus, most homes would experience some flood damages. If flood depth

does not exceed 0.5 m, 24 homes (16%) would receive minimal damage.[4] Potential damages to a 0.5 m depth could be reduced for an additional 39 dwellings by requiring removable closures for, or permanently sealing, basement windows. Government financial incentives would probably be necessary to gain flood plain resident cooperation.

Midlandvale could be protected by dykes. Preliminary studies indicated that 11 properties would have to be purchased and that the dykes would be 2 to 3 m high, if the Red Deer Dam is built. Property values of the remaining homes would likely drop significantly if the river view is lost. Considerable opposition could be anticipated from the ten owners of homes built along North River Drive in the past decade which have never experienced flooding.

Public purchase of the 1:25 or 1:100 year flood plain would involve relocating approximately 137 families and one commercial establishment. The social and economic costs, in all likelihood, would be prohibitive.

7.3.3 Recommendations for Future Land Use Policies

Because Midlandvale is an established community, it is recommended that existing flood plain development be protected by a low dyke along North River Drive, in conjunction with a flood proofing program. Together, these measures could be used to protect the community to the 1:100 year flood level. Gate valves and removable basement window closures

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[4] More information about flood frequencies and flood damages will be provided in the "flood damage and flood proofing" component of the Drumheller Valley Flood Control Study.

could be required for existing buildings, while new buildings could be raised on fill and equipped with gate valves. Part of these costs, particularly for existing development, could be paid by the provincial government through the savings from building smaller dykes. However, the flood proofing costs would probably exceed the savings from building smaller dykes. A development permit should be required for new single family residences built on the flood plain behind the dykes, to ensure that flood proofing is undertaken and that development is compatable with the flood hazard.

Since the floodway and floodway fringe overlap, new subdivision and development should be directed away from this area, to the area north of the Dinasour Trail (appendix C). Several new residential subdivisions have been developed in this area in recent years; new subdivisions should be located here, rather than on the flood plain. Development of the two land parcels in East Midlandvale has been approved; however, additional subdivision of the remaining vacant flood plain land in Midlandvale should not be allowed. Otherwise, there will be no vacant flood plain land left in Midlandvale to form the riverside parkland recommended in the General Plan (1977, recommendation 31). The remaining land should be purchased or development should be controlled by the City.

7.4 Newcastle

7.4.1 Land Use

In Newcastle, 172 buildings were located on the 1:100 year flood plain (appendix C). Eighty-nine percent of these were also on the 1:50 year flood plain and 63% were on the 1:25 year flood plain. On the 1:100

year flood plain, there were 127 single family residences, 28 squatters, 13 duplexes and 2 commercial establishments, one hotel and one community hall (Table 7.3). One hundred and eight buildings (63%) were built prior to 1940; 5 of these (5%) were unoccupied. Fifty-two buildings (30%) have been built since 1970; 7 of these (13%) were unoccupied because construction was not complete. The remaining 7% were built between 1940 and 1970; one was unoccupied.

According to the Alberta Department of Municipal Affairs classification, 1 building was class B, 22 were class C and 30 were class D. Five class C dwellings were under construction, one class D dwelling was for sale. Forty-four buildings were class E and 53 were class F. Six of these were unoccupied. Finally, 22 mobile homes were located in Newcastle; one was unoccupied at the time of the field survey. The majority of buildings (32%) were in good condition; 16% were in poor condition.

Forty-three percent of the buildings had a basement water entry point. The majority of these (48) had a basement opening less than 0.5 m above the ground and a first floor 0.6 m to 1.0 m above the ground. Fifty-eight percent of these (80) had first floors less than 0.5 m above ground level.

In 1978, the western portion of Newcastle was zoned for general residential uses, except for the south-east corner, which was highway commercial (appendix C). The eastern subdivided portion was also zoned for general residential development. The Newcastle flats, where 32 squatters lived on city-owned property, was zoned as a direct-control district. All development in this district must have the approval of the municipal planning commission (City of Drumheller 1976).

Table 7.3

NEWCASTLE: LAND USE AND BUILDING DESCRIPTION

Variable	occupied buildings	unoccupied buildings	total buildings (number)	(percent)
Land Use[a]				
single family residential	122	5	127	73%
two family residential	7	6	13	8%
squatter	26	2	28	16%
commercial	2	0	2	1%
hotel	1	0	1	1%
public	1	0	1	1%
Building Age[b]				
pre-1940	103	5	108	63%
1940-1949	7	0	7	4%
1950-1959	2	1	3	2%
1960-1969	1	0	1	1%
post 1970	45	7	52	30%
Building Class[b]				
B	1	0	1	1%
C	17	5	22	13%
D	29	1	30	17%
E	40	4	44	26%
F	51	2	53	31%
mobile	21	1	22	13%
Building Condition[a]				
good	51	7	58	34%
fair to good	23	0	23	13%
fair	44	0	44	26%
fair to poor	15	1	16	9%
poor	26	5	31	18%
Lowest Water Entry Point[a]				
First Floor Only				
0-0.5 meter	75	5	80	47%
0.6-1.0 meter	16	1	17	10%
+1.0 meter	1	0	1	1%
Basement/First Floor				
0-0.5/0-0.5 meter	18	6	24	14%
0-0.5/0.6-1.0 meter	47	1	48	28%
0-0.5/+1.0 meter	2	0	2	1%

Source: a) Field Survey, conducted by the author, September, 1978.
b) Municipal Tax Assessment Forms, August, 1978.

Note: The criteria for each variable are discussed in chapter two (section 2.5).

7.4.2 Alternative Land Use Policies

a) Vacant Undeveloped Land

In Newcastle there were no large blocks of vacant land that could be purchased publicly. The Newcastle flats were owned by the City of Drumheller in 1978. This land was used for a park and campground, except where the area was inhabited by squatters (appendix C).

b) New Subdivision Applications

The only land available for subdivision in Newcastle is the Newcastle flats. Although this land is to be converted to parkland as the squatters leave (Guidolin 1978), some subdivision and subsequent sale of lots has been allowed in the southwest corner (appendix C). If further subdivision of the 1:100 or 1:25 year flood plain is not allowed, this land will become parkland as squatters leave. If subdivision with flood proofing is allowed on the floodway fringe, the six lots inhabited by squatters in the southwest corner could be subdivided, provided new development is flood proofed (appendix C). If a policy is adopted to allow subdivision of the flood plain without flood proofing, the squatters may put pressure on the City to subdivide the land.

c) Vacant Subdivided Lots

In 1978, there were twenty vacant lots and five unoccupied poor-condition dwellings on the Newcastle 1:100 year flood plain (appendix C). Under the existing bylaw, these lots could be developed without a development permit for single family residential uses. If development occurred without flood proofing, potential flood damages would increase. If new development is allowed on the floodway fringe only, with flood proofing,

12 of the vacant lots could be developed. If development of the entire flood plain is allowed with flood proofing, all lots could be developed and flood damage potential would be increased only slightly.

d) Developed Subdivided Lots

Eighty-nine percent of existing development had a water entry point less than 0.5 m above the ground. In the event of a 1:100 year flood, the entire Newcastle flood plain would be inundated to a depth of 0.5 to 3.0 m. Thus, almost all homes would experience flood damages. If flood levels do not exceed 0.5 m, 18 buildings (11%) would receive minimal flood damage. Potential damages to a 0.5 m level could be reduced for an additional 50 dwellings by requiring removable closures or permanent sealing of basement windows. Government financial incentives would likely be necessary to gain cooperation of flood plain residents.

Newcastle could be protected with a dyke to a selected flood frequency. In a preliminary study, it was estimated that a dyke would have to be 4 m high to protect Newcastle from a 1:100 year flood, taking the protection of the Red Deer Dam into account. Some property along Riverside Avenue may have to be purchased. If the homes are left, property values may drop significantly, if the dykes obstruct the river view. In addition, the decision will have to be made as to whether or not to protect the Newcastle squatters. If the squatters are protected, it is likely that gradual subdivision and development of the Newcastle flats will continue. But, if the squatters are not protected, their property may be damaged in the event of a flood and they may decide to move to safer ground, especially if compensation is provided to relocate rather than to rebuild on the flood plain.

Public purchase of the 1:100 year flood plain would involve relocation of 159 homes and businesses, 52 of which have been built in the past decade. Public purchase of the 1:25 year flood plain would involve 108 homes and businesses, 24 of which have been built in the past decade. Public purchase of the squatters' dwellings, rather than allowing further subdivision of the Newcastle flats may be possible since 32 houses are involved and the land is already owned by the City of Drumheller.

7.4.3 Recommendations for Future Land Use Policies

Newcastle is a well-established community, thus, it is recommended that existing development, excluding the squatters, be protected by a low dyke, lower than the 4 m dyke proposed by Klohn Leonoff, in conjunction with a flood proofing program. Together, these measures could be used to protect the existing community to the 1:100 year flood level, taking the effects of the Red Deer Dam into account. If the City of Drumheller does not intend to give the squatters title to the land they inhabit, this area should not be protected. This would reduce the height and cost of the dykes, because they could be built away from the river in the eastern portion of Newcastle and leave the parkland unprotected. If the dyke is built along Riverside Avenue and on City property minimal private property would have to be purchased. Gate valves and removable or permanent basement window closures could be required for existing buildings; new buildings could be raised on fill or otherwise protected to the 1:100 year flood level, taking dyke protection into account, and equipped with gate valves to prevent basement flooding. Part of these costs could be paid by the provincial government through

the savings from smaller dykes. However, the flood proofing would probably cost more than the savings from smaller dykes.

A development permit should be required for new single family dwellings being constructed on existing lots to ensure that flood proofing is undertaken and the flood hazard is not increased. New subdivision and development of the Newcastle flats should not be allowed if this area is not protected. New subdivision and development should be directed south of the Newcastle Trail (appendix C). The Newcastle flats should be maintained as a campground, recreation area or other non-intensive use in the future.

7.5 North Drumheller

7.5.1 Land Use

In North Drumheller, the flood plain was designated by combining the flows of Michichi Creek and the Red Deer River for the selected flood frequencies. Thus, the 1:100 year flood plain, for example, is based on simultaneous 1:100 year floods occuring on the Red Deer River and Michichi Creek. The likelihood of this occuring is low; the Alberta Department of the Environment is considering the worst possible case, in this instance.

In 1978, 116 buildings were located on the North Drumheller 1:100 year flood plain (appendix D). Ninety-eight percent were also on the 1:50 year flood plain and 86% were on the 1:25 year flood plain. On the 1:100 year flood plain there were 100 single family dwellings, 10 commercial establishments, four light industrial businesses and 2 motels (Table 7.4). Seventy-two buildings (62%) were built prior to 1940. Twenty-four buildings (21%) have been built since 1970. The remaining 20 (17%)

Table 7.4

NORTH DRUMHELLER: LAND USE AND BUILDING DESCRIPTION

Variable	occupied buildings	unoccupied buildings	total buildings (number)	(percent)
Land Use[a]				
single family residential	100	0	100	86%
commercial	10	0	10	9%
industrial/storage	4	0	4	3%
hotel	2	0	2	2%
Building Age[b]				
pre-1940	72	0	72	62%
1940-1949	5	0	5	4%
1950-1959	7	0	7	6%
1960-1969	8	0	8	7%
post 1970	24	0	24	21%
Building Class[b]				
C	27	0	27	23%
D	29	0	29	25%
E	18	0	18	16%
F	37	0	37	32%
mobile	4	0	4	3%
quonset	1	0	1	1%
Building Condition[a]				
good	41	0	41	35%
fair to good	24	0	24	21%
fair	36	0	36	31%
fair to poor	9	0	9	8%
poor	6	0	6	5%
Lowest Water Entry Point[a]				
First Floor Only				
0-0.5 meter	38	0	38	33%
0.6-1.0 meter	1	0	1	1%
+1.0 meter	1	0	1	1%
Basement/First Floor				
0-0.5/0-0.5 meter	9	0	9	8%
0-0.5/0.6-1.0 meter	60	0	60	52%
0-0.5/+1.0 meter	7	0	7	6%

Source: a) Field Survey, conducted by the author, September, 1978.
b) Municipal Tax Assessment Forms, August, 1978.

Note: The criteria for each variable are discussed in chapter two (section 2.5).

were built between 1940 and 1970. No flood plain buildings were unoccupied in North Drumheller.

According to the Alberta Department of Municipal Affairs classification, 27 buildings were class C, 29 were class D, 18 were class E and 37 were class F. There were four mobile/modular homes and a quonset was used by MacLean Construction for a workshop and storage. The majority of buildings (35%) were in good condition; only 5% were in poor condition.

Sixty-six percent of the buildings had a basement water entry point. The majority of these (60) had a basement opening less than 0.5 m above the ground and a first floor 0.6 to 1.0 m above the ground. Thirty-five percent of the buildings (40) had no basement water entry point; the majority of these (38) had first floors less than 0.5 m above ground level.

Five dwellings had been raised to the 1:25 year flood level on fill. Three of these were new houses in the R-1 district west of Michichi Creek, and two, built in the 1950s following several floods, were in the direct-control district east of Michichi Creek (appendix D). Two other new dwellings in the same direct control district have not been flood proofed to the 1:25 year flood level. The new Rockhound Motel, restaurant and store in the highway commercial district east of Highway Number 9 were raised on fill to the 1:25 year flood level, according to the flood plain maps prepared by Klohn Leonoff Consultants Limited.

7.5.2 Alternative Land Use Policies

a) Vacant Undeveloped Land

In North Drumheller, there was no vacant flood plain land that

could be converted to parkland/open space. In the west portion of North Drumheller, a large section of land, which was used for recreation and an abandoned gravel pit was owned by the federal government in 1978. The City of Drumheller was trying to purchase this property (Guidolin 1978).

b) New Subdivision Applications

There were three areas which may, in future be subdivided: the R-1 district at the mouth of Michichi Creek, the direct-control district and the mobile home parks (appendix D). All were on the 1:100 year flood plain. If no further subdivision of the 1:100 year flood plain is allowed, none of these areas could be subdivided. If subdivision with flood proofing to the 1:100 year flood level is allowed, these low-lying areas would have to be raised three to four meters on fill or otherwise flood proofed. Not only would this be costly, but it could increase backwater flooding. If subdivision is allowed on the floodway fringe, only the northern mobile home park could be subdivided, since the 1:100 and 1:25 year flood lines virtually coincide through most of North Drumheller (appendix D). If further development is allowed on the 1:100 year flood plain without flood proofing to the 1:100 year flood level, potential flood damages would increase. This low, flat land was flooded frequently before Michichi Creek was channelized, and it is for this reason that the low flat land at the Michichi Creek mouth is sparsely settled.

If the 1:100 year flood plain is required as environmental reserve, then, no further subdivision of North Drumheller could occur. If the 1:25 year flood plain is required, only the mobile home park could be

subdivided. If a designated width is required, the flat areas at the mouth of Michichi Creek could be subdivided, depending upon the effect of backwater flooding. A buffer zone of parkland or open space would be left along Michichi Creek and the Red Deer River.

c) Vacant Subdivided Lots

There were about 30 vacant lots and no unoccupied dwellings in North Drumheller. During this study, several new homes, being constructed on previously subdivided lots were observed. Presently, no development permit is required to construct single family homes in residential districts on the flood plain. Thus, many of the new dwellings have been built without being raised on fill or otherwise flood proofed; others have been flood proofed to the 1:25 year flood level. If further development of existing lots on the 1:100 year flood plain, or even the flood way, is not allowed, none of these lots could be developed. If these lots could be developed with flood proofing to the 1:100 year flood line, damage to the 1:100 year flood plain would not be increased and could actually decrease if old dwellings are replaced with new flood proofed buildings. However, if future development of the flood plain is allowed without flood proofing, potential flood damages will increase.

d) Developed Subdivided Lots

Some existing development has been raised on fill to the 1:25 year flood level, for example, the Rockhound Motel complex and several dwellings built at the mouth of Michichi Creek. In the event of a 1:100 year flood, the entire North Drumheller flood plain would be inundated to a depth of one to four meters. Forty-one percent of the buildings (47)

would be inundated to the first floor level by 0.5 m of flood water; nine of these would also have basement flooding. If basement water entry points are sealed or provided with removable closures, an additional 14 buildings would not be inundated by flood waters of less than 0.5 m depth. Thus, flood proofing existing dwellings and other buildings could provide protection for high frequency, low volume floods. Government financial incentives would probably be necessary to gain public co-operation. Best cooperation would probably result following a major flood event, as evidenced by the flood proofed homes built following the 1950s floods.

North Drumheller could be protected by dykes. Preliminary studies indicated that the dykes would be approximately 3 m high to protect the area from the 1:100 year flood that would occur, taking the effects of the Red Deer Dam into account.

Public purchase of the 1:25 or 1:100 year flood plain would involve relocating over one hundred families, commercial and industrial establishments. The social and economic costs, in all likelihood, would be prohibitive.

7.5.3 Recommendations for Future Land Use Policies

Since North Drumheller is a well-established community and is virtually entirely located on the floodway (appendix D), it is recommended that the developed area be protected by a low dyke (lower than the 3 m recommended by Klohn Leonoff), in conjunction with flood proofing for new and existing development. There is already a dyke along part of Michichi Creek, although it does not extend to the creek mouth (appendix D). Much of the new development in North Drumheller has occurred on the flats

at the mouth of Michichi Creek, in the unprotected D-C and R-1 districts (appendix D). Dykes should be located to ensure that a maximum amount of riverside parkland is maintained between the dyke and the river, and to minimize the amount of developable land behind the dykes.

New development in the direct control district should be controlled more strictly by the City, than it has been in the past, to ensure that no further development of this area occurs without flood proofing. Gate valves and removable basement window closures could be required for existing flood plain buildings. New buildings should be raised on fill or otherwise flood proofed to the 1:100 year level, taking dyke protection into account and equipped with gate valves to prevent basement flooding. Part of these costs could be paid by the provincial government with the cost savings from smaller dykes. Initial flood proofing of existing buildings would probably cost more than the cost savings from smaller dykes. A development permit should be required for all new single family dwellings, to ensure that development is compatable with the flood hazard.

New subdivision and development should not be allowed on the North Drumheller flood plain, even if the low-lying area is protected with dykes. The existing open space should be maintained, especially the land in the western portion, which was owned by the federal government in 1978. Purchase of flood plain land by the City should be considered, if property owners are willing to sell land, such as the campground, to ensure that it is not purchased by individuals speculating for future subdivision and development.

7.6 Drumheller

7.6.1 Land Use

The community of Drumheller is the most eastern community in the City of Drumheller and is located south of the Red Deer River (Figure 1.1). In Drumheller, there were 94 buildings on the 1:100 year flood plain in 1978. Eighty-eight percent of these were also located on the 1:50 year flood plain and 74% were on the 1:25 year flood plain. On the 1:100 year flood plain, there were 81 single family residences, one apartment building, 5 commercial establishments, two industrial facilities (water sewage and power station), one motel and four publicly-owned recreation complexes (Table 7.5). Seventy-two buildings (78%) were built prior to 1940; four of these (6%) were unoccupied. Only two buildings have been constructed since 1970. The remaining 21% were built between 1940 and 1970; all were occupied.

According to the Alberta Department of Municipal Affairs classification, two buildings were class B and 20 were class C. The majority were class D and one of these was unoccupied. The majority of buildings were in fair (38%) and fair to good (35%) condition; only 2% were in poor condition.

Sixty-five percent of the flood plain buildings had a basement water entry point. The majority of these (42) had a basement opening less than 0.5 m above the ground and a first floor opening 0.6 to 1.0 m above the ground. Thirty-five percent of the buildings (31) had no basement water entry point; the majority of these (29) had first floors less than 0.5 m above ground level.

Within the 1:100 year flood plain, the majority of land was zoned for light industrial uses, which included recreation facilities, park-

Table 7.5

DRUMHELLER: LAND USE AND BUILDING DESCRIPTION

Variable	occupied buildings	unoccupied buildings	total buildings (number)	(percent)
Land Use[a]				
single family residential	77	4	81	86%
multi family residential	1	0	1	1%
commercial	5	0	5	6%
industrial/storage	2	0	2	2%
hotel	1	0	1	1%
public	4	0	4	4%
Building Age[b]				
pre-1940	68	4	72	78%
1940-1949	3	0	3	3%
1950-1959	12	0	12	13%
1960-1969	5	0	5	5%
post 1970	2	0	2	2%
Building Class[b]				
B	2	0	2	2%
C	29	0	29	31%
D	44	1	45	48%
E	4	0	4	4%
F	11	3	14	15%
Building Condition[a]				
good	20	0	20	21%
fair to good	33	0	33	35%
fair	33	3	36	38%
fair to poor	2	0	2	2%
poor	2	1	3	2%
Lowest Water Entry Point[a]				
First Floor Only				
0-0.5 meter	27	2	29	31%
0.6-1.0 meter	4	0	4	4%
Basement/First Floor				
0-0.5/0-0.5 meter	12	0	12	13%
0-0.5/0.6-1.0 meter	40	2	42	45%
0-0.5/+1.0 meter	8	0	8	7%

Source: a) Field Survey, conducted by the author, September, 1978.
b) Municipal Tax Assessment Forms, August, 1978.

Note: The criteria for each variable are discussed in chapter two (section 2.5).

land, motels and so forth (appendix D). Several commercial buildings were located in the central business district, and the remainder was zoned for general residential uses.

7.6.2 Alternative Land Use Policies

a) Vacant Undeveloped Land

In 1978, much of the vacant land on the Drumheller flood plain was in the light industrial district and was used by the City of Drumheller for recreation purposes. One parcel, between the medical clinic and the Dinasour was privately owned, subdivision of this property had been proposed (Fenwick 1979c). Owner opposition to proposals for public purchase of this property could be anticipated.

b) New Subdivision Applications

If the PRPC decided to disallow 1:100 or 1:25 year flood plain subdivision, the proposed subdivision would not be allowed. If it is allowed, about 3 m of fill will be needed to raise the land to the 1:100 year flood level. If the floodway fringe is designated as the area between the 1:25 and 1:100 year flood lines, very little new development could occur, as this area is very small and already subdivided and developed (appendix D). If further subdivision of the Drumheller flood plain is not allowed, it will make little difference to potential flood damages because the flood plain is quite densely developed and most of the undeveloped land is owned by the City of Drumheller.

If the 1:100 year of 1:25 year flood plain is required as environmental reserve, no additional subdivision of the Drumheller flood plain would be possible. If a designated distance from the river is required,

some land in the light industrial district could potentially be subdivided and developed.

c) Vacant Subdivided Lots

It is unlikely that there will be pressure to develop existing flood plain lots, since there was only one vacant lot and several unoccupied dwellings in this part of Drumheller. Only two buildings have been constructed in this area since 1970.

d) Developed Subdivided Lots

In the event of a 1:100 year flood, existing unprotected riverside development, such as the new Aquaplex, could be inundated by as much as 4 m of water. Most of the dwellings were on higher ground, and would only be inundated to a maximum depth of one meter during a 1:100 year flood. The medical center, pharmacy and power plant have been raised on fill to the 1:25 year flood level. Thirty-one percent of the flood plain buildings had first floors less than 0.5 m above the ground; flood proofing would do little to reduce flood damages. However, 56% of the buildings could be protected to at least the 0.5 m level by requiring closures or seals for basement openings of the 50 buildings with first floors higher than 0.5 m above the ground. In order to gain cooperation, government financial incentives would probably be necessary.

To protect this area, little private land would have to be purchased for dyke construction, because the structures could be built on public property. The dyke height could be minimized by locating the structures as far away from the river as possible.

Public purchase of the private property on the flood plain would be expensive and impractical because this area is intensely developed. However, it may be possible for the City to gradually purchase some properties along Riverside Avenue, as they come up for sale (appendix D).

7.6.3 Recommendations for Future Land Use Policies

Most of the Drumheller flood plain is already owned by the City of Drumheller and is used for parkland, recreation and other public facilities. These uses are compatable with the flood hazard. The subdivided, developed portion of the Drumheller flood plain is an established community. Existing development could be protected by constructing a low dyke in the parkland area, as far back from the river as possible, while still protecting the existing recreational facilities. Flood proofing existing development would provide added protection. The dykes could be constructed entirely on public property. Gate valves and removable basement window closures could be required for existing development. Conversations with Drumheller residents revealed that some people had these installed following the 1950s floods. If new buildings are constructed on subdivided lots behind the dykes, these should be raised on fill or otherwise flood proofed to the 1:100 year flood level, taking the dyke protection into account. A development permit should be required for new single family development on existing lots, to ensure that it is compatable with the flood hazard.

New subdivision and development of the flood plain should not be allowed in the protected area. The existing parkland and recreational facilities should be maintained and expanded, if the opportunity arises.

7.7 Nacmine

7.7.1 Land Use

In the hamlet of Nacmine, 48 buildings were located on the 1:100 year flood plain (appendix E). Forty-six percent of these were also on the 1:50 year flood plain and 10% were on the 1:25 year flood plain. On the 1:100 year flood plain, there were 45 single family residences, one general store and two light industrial storage facilities (Table 7.6). Thirty buildings (63%) were built prior to 1940, six of these were unoccupied. Fourteen buildings (29%) had been constructed since 1970; one was unoccupied because it was under construction. The remaining four (8%), which were built in the 1960s, were occupied.

According to the Alberta Department of Municipal Affairs classification, 7 buildings were class C and 8 were class D. One class C dwelling was under construction. Eight buildings were class E and three of these were unoccupied. Finally, 6 mobile homes were located on the 1:100 year flood plain. The majority of buildings (34%) were in good condition, but 22% were in poor condition.

Twenty percent of the buildings had a basement water entry point. The majority of these (8) had a basement opening less than 0.5 m above the ground and a first floor 0.6 to 1.0 m above the ground. Eighty percent of the buildings (33) had no basement water entry point; the majority of these (28) had first floors less than 0.5 m above ground level.

In 1978, all of Nacmine, except for the commercial strip along the highway, was zoned for general residential uses (appendix E).

Table 7.6

NACMINE: LAND USE AND BUILDING DESCRIPTION

Variable	occupied buildings	unoccupied buildings	total buildings (number)	(percent)
Land Use[a]				
single family residential	38	7	45	93%
commercial	1	0	1	2%
industrial/storage	2	0	2	5%
Building Age[b]				
pre-1940	24	6	30	63%
1960-1969	4	0	4	8%
post 1970	13	1	14	29%
Building Class[b]				
C	6	1	7	15%
D	8	0	8	17%
E	8	3	11	23%
F	12	3	15	31%
mobile	6	0	6	13%
quonset	1	0	1	2%
Building Condition[a]				
good	14	2	16	33%
fair to good	6	0	6	13%
fair	10	0	10	21%
fair to poor	2	2	4	8%
poor	9	3	12	25%
Lowest Water Entry Point[a]				
First Floor Only				
0-0.5 meter	28	5	33	69%
0.6-1.0 meter	5	0	5	10%
Basement/First Floor				
0-0.5/0-0.5 meter	2	0	2	4%
0-0.5/0.6-1.0 meter	6	2	8	17%

Source: a) Field Survey, conducted by the author, September, 1978.
b) Municipal Tax Assessment Forms, August, 1978.

Note: The criteria for each variable are discussed in chapter two (section 2.5).

7.7.2 Alternative Land Use Policies

a) Vacant Undeveloped Land

In Nacmine, public purchase of the vacant, undeveloped 1:25 year flood plain land would reduce flood damages from future development since, at present, most of the 1:25 year flood plain is open space or used for agriculture (appendix E). Opposition to this type of policy could be anticipated from the present owners who may intend to subdivide and develop this land in the future. In particular, the owner of Block E (the large block of undeveloped land in the center of Nacmine) has submitted a subdivision application to the PRPC (Fenwick 1979c).

b) New Subdivision Applications

The western portion of Nacmine has been subdivided into residential lots, but the eastern portion was less densely subdivided and developed in 1978 (appendix E). In fact, Block E was used for a horse pasture, the next two properties to the east were cultivated and the next property was used for raising goats; the latter property was for sale. If further subdivision of the Nacmine 1:100 year flood plain is not allowed, virtually all of the vacant land parcels within the hamlet boundaries could not be subdivided. If subdivision of the 1:100 year flood plain is allowed with flood proofing to the 1:100 year level, subdivision of Block E and the other undeveloped land could be allowed, depending upon the effects on backwater flooding. About 1.0 to 1.5 m of fill would be needed to raise this property above the 1:100 year flood level. If subdivision of the floodway fringe, only, is allowed with fill to the 1:100 year flood level, a portion of Block E could be subdivided (appendix E).

The flood plain maps show that subdivision of the 1:25 year flood

plain has been avoided in the past. This may be due, in part, to past flooding experiences in this area or perhaps due to a high water table (appendix E). If the subdivision applicant is required to provide the 1:100 year flood plain as environmental reserve, there could be be virtually no additional subdivision of eastern Nacmine. If he is required to provide the 1:25 year flood plain as environmental reserve, a large portion of potential subdivisions, such as Block E, could be required by the PRPC. However, if the province compensated the subdivision applicant for this land, the present amount of riverside open space could be maintained and potential flood damages would not be increased. If a designated width of flood plain is required as reserve by the PRPC, a buffer zone of open space would be provided between new development and the river to carry peak flows and, perhaps, to be used as parkland.

c) Vacant Subdivided Lots

In 1978, there was potential for development on 13 subdivided lots and on 8 lots with unoccupied dwellings on the Nacmine 1:100 year flood plain. There were numerous vacant, subdivided lots that were not on the flood plain in Nacmine. If further subdivision of the 1:100 year flood plain is not allowed, further development of these vacant subdivided flood plain lots would provide a complimentary policy. If development is allowed only on the floodway fringe with flood proofing, to the 1:100 year flood level, all presently available subdivided, vacant lots could be developed with 0.5 to 1.0 m of fill. If development is allowed on the entire flood plain, as much as 1.5 m of fill could be necessary in areas close to the river. As recently as 1977, development of the 1:50 year flood plain, at the river edge, was permitted without flood proofing.

d) Developed Subdivided Lots

Ninety percent of existing development (43 dwellings) had a water entry point less than 0.5 m above the ground. In the event of a 1:100 year flood, the Nacmine flood plain would be inundated to a depth of 0.5 to 1.5 m. Thus, almost all homes on the flood plain would experience flood damages. If eight homes are flood proofed with basement window seals or closures, 13 dwellings would be protected for floodwaters to a 0.5 m depth. Nevertheless, 73% of the buildings first floors would be inundated at a one-meter flood depth.

If Nacmine is protected with control structures, several homes would probably have to be purchased, including a home built in 1977. Depending upon where the structures are situated, their presence could encourage applications for subdivision and development of vacant land behind the dykes on the flood plain.

Public purchase of existing development on the 1:100 year flood plain would involve 40 occupied dwellings, one general store and 7 unoccupied buildings. Considerable public opposition could be anticipated. Purchase of the 1:25 year flood plain would involve only five occupied buildings, as most of this area is presently undeveloped.

e) Abandoned Buildings

There were seven abandoned buildings on the Nacmine 1:100 year flood plain. Their removal would reduce the number of flood plain buildings by 15% and would prevent new occupants from moving in and upgrading these buildings without flood proofing.

7.7.3 Recommendations for Future Land Use Policies

In 1978, only a small portion of the subdivided portion of Nacmine was located on the flood plain; moreover, only five dwellings were located on the 1:25 year flood plain. Thus, it is recommended that Nacmine not be protected by dykes. Instead, a strict land use management policy, based on a two-zone flood plain, should be adopted by the Improvement District to control new flood plain development in Nacmine. New residential and commercial development should not be allowed on the 1:25 year flood plain. New development of the floodway fringe, could be allowed, provided it is flood proofed to the 1:100 year flood level. Eleven of the 31 occupied flood plain dwellings could be flood proofed by adding removable closures for basement windows. A further study is necessary to determine the feasibility of flood proofing remaining dwellings, commercial and storage facilities. In addition, removal of the 7 unoccupied, dilapitated buildings would prevent new people from moving in without flood proofing and reduce the flood damage potential.

New subdivision and development of Nacmine should be directed south of First Street (appendix E). This land is currently owned by the Monarch Coal Company. Because the mine is no longer operating, the coal company may be willing to subdivide and sell part of the property, if there is a demand for new dwellings in Nacmine. In 1978, there were at least 20 vacant lots in Nacmine, which were not on the floodway. These should be able to handle the demand for new housing in the near future, since only 14 dwellings have been built on the entire Nacmine flood plain in the past 8 years. The low land in Nacmine should be retained for agricultural use; this could be encouraged by changing the zoning from hamlet-residential to conservation-agriculture. Alternatively, public

purchase of the 1:25 year flood plain should be investigated by the municipal government, if the Nacmine flood plain is to be included in the riverside parkland scheme outlined in the General Plan (1977, recommendation 31).

7.8 Rosedale (including the Aerial flats)

7.8.1 Land Use

In Rosdedale, 87 buildings were located on the 1:100 year flood plain (appendix F). Ninety-three percent of these were also on the 1:50 year flood plain and 59% were on the 1:25 year flood plain. The majority of these were east of the Rosebud on the Aerial flats (Figure 1.1). Very few buildings in the hamlet of Rosedale, west of the Rosebud River, were on the flood plain (appendix F). On the 1:100 year flood plain, there were 53 single family dwellings and 32 squatters (Table 7.7). The squatters' property was owned by private individuals, although it used to be owned by the coal mining companies. One squatter's building was a snack bar; the remainder were dwellings. Seventy-two buidings (83%) were built prior to 1940; 8 or these (9%) were unoccupied. The 13 buildings constructed since 1970 were occupied. The remaining two buildings were constructed in the 1950s.

According to the Alberta Department of Municipal Affairs classification, 11 buildings were class C, 10 were class D and 19 were class E. One class E dwelling was unoccupied. The majority (42) were class F; 7 of these were unoccupied. Finally, four mobile homes were located in Rosedale. The majority of buildings were in fair (28%) and poor (29%) condition. Only 15 buildings (19%) were in good condition.

Nineteen percent of the buildings had a basement water entry point.

Table 7.7

ROSEDALE: LAND USE AND BUILDING DESCRIPTION

Variable	occupied buildings	unoccupied buildings	total buildings (number)	(percent)
Land Use[a]				
single family residential	48	5	53	64%
squatter	31	3	34	36%
Building Age[b]				
pre-1940	64	8	72	83%
1950-1959	2	0	2	2%
post 1970	13	0	13	15%
Building Class[b]				
C	11	0	11	13%
D	10	0	10	11%
E	19	1	20	23%
F	35	7	42	48%
mobile	4	0	4	5%
Building Condition[a]				
good	15	0	15	17%
fair to good	7	0	7	8%
fair	22	1	23	26%
fair to poor	12	0	12	14%
poor	23	7	30	34%
Lowest Water Entry Point[a]				
First Floor Only				
0-0.5 meter	62	8	70	80%
+1.0 meter	1	0	1	1%
Basement/First Floor				
0-0.5/0-0.5 meter	1	0	1	1%
0-0.5/0.6-1.0 meter	14	0	14	17%
0-0.5/+1.0 meter	1	0	1	1%

Source: a) Field Survey, conducted by the author, September, 1978.
b) Municipal Tax Assessment Forms, August, 1978.

Note: The criteria for each variable are discussed in chapter two (section 2.5).

The majority of these (14) had a basement opening less than 0.5 m above ground level and a first floor 0.6 to 1.0 m above the ground. Seventy-nine percent of the buildings (71) had no basement water entry point; the majority of these (80) had first floors less than 0.5 m above ground level.

The subdivided portion of the Rosedale flood plain was zoned for hamlet residential uses in 1978 (appendix F). The area inhabited by squatters in Aerial was zoned for conservation-agricultural uses.

7.8.2 Alternative Land Use Policies

a) Vacant Undeveloped Land

Much of the Rosedale flood plain adjacent to the Red Deer River was vacant and owned privately, especially in the Aerial flats. This land is very low and could potentially be purchased by the government to avoid future applications for subdivision and development.

b) New Subdivision Applications

There was much vacant land on the Rosedale flood plain, particularly on the Aerial flats. No applications for subdivision of this area have been made recently. However, there may be some pressure from the squatters to receive title to the land they occupy. For example, the area west of the squatters was recently subdivided and the eleven squatters were given title to the land they occupied (appendix F). If subdivision of the flats is allowed for new development, with flood proofing to the 1:100 year flood level, up to 5 m of fill would be needed in some areas. This would be expensive. If subdivision of the squatter areas is allowed, flood proofing of the existing development would be impractical because

most houses are less than 0.5 m above ground level and are poorly constructed. The distance between the 1:25 and 1:100 year flood levels is so small in Rosedale, that there is virtually no floodway fringe. If the entire flood plain could be subdivided without flood proofing, the flood hazard potential could increase significantly. However, there seems to be little development pressure in Rosedale, at the present time.

If either the 1:25 or 1:100 year flood plain is required for environmental reserve from new subdivisions, a vast amount of land area would be involved. However, since a small portion of the hamlet of Rosedale, excluding the Aerial flats, is on the flood plain, this may, indeed reflect the potential flood hazard, and point to the need to restrict future flood plain development. Requiring a standard width of environmental reserve is impractical for an area such as Rosedale, where the flood plain width varies widely and is undeveloped.

c) Vacant Subdivided Lots

There were only 8 vacant subdivided lots and 5 old unoccupied dwellings, excluding squatters, on the 1:100 year Rosedale flood plain. Thus, there were at least 13 potentially developable flood plain lots. If further development of the 1:100 year flood plain is not allowed, these lots could not be developed. However, public purchase or monetary compensation could be considered by government authorities to reduce owner opposition. If development is allowed with flood proofing, several meters of fill may be required to raise some of these lots to the 1:100 year flood level. If new development is allowed on the floodway fringe only, development of at least 6 lots in the subdivided areas of the flood plain

would be possible.

d) Developed Subdivided Lots

Ninety-nine percent of the flood plain buildings in Rosedale and Aerial had a water entry point less than 0.5 m above the ground in 1978 (appendix F). In the event of a 1:100 year flood, the Rosedale flood plain would be inundated to a depth of 0.5 to 5 m. Thus, virtually all buildings would experience some flood damage. Potential damages for floodwaters less than 0.5 m deep could be reduced for 18% of the buildings by sealing or flood proofing basement water entry points.

Before adopting a program to protect Rosedale with dykes, a policy should be adopted by the Alberta Department of Municipal Affairs for the squatters in the Drumheller Valley. Without the squatters, there only 43 occupied dwellings on the Rosedale flood plain. The cost to protect the small subdivided area with dykes would be much less than to protect the entire Aerial flats (appendix F). Moreover, once the Aerial flats are protected from flooding, it can be anticipated that development pressure would occur, not only from squatters, but also from people wanting to establish acreages, such as those south of the Aerial squatters (appendix F).

e) Abandoned Buildings

There were 8 abandoned buildings on the Rosedale flood plain. Their removal would reduce the number of flood plain buildings in Rosedale and the Aerial flats by 10%.

7.8.3 Recommendations for Future Land Use Policies

Only a small portion of the subdivided portion of Rosedale was located on the flood plain (appendix F). Thirty-one of the 70 occupied flood plain buildings (39%) were owned by squatters. At least until a policy is developed to deal with the squatters, the Rosedale flood plain should not be protected with dykes. It is recommended that the squatters not be given title to the land; as they leave, the dwellings should be removed and the land returned to agricultural use. Most of the squatters dwellings were so low and in such poor condition that they could not be flood proofed. If the squatters are given title, they could build new homes or sell the property to developers. New development, for residential purposes, should not be encouraged in this low-lying, flood-prone area.

A land use management policy, based on a two-zone flood plain, should be adopted by the municipality to control new flood plain development in Rosedale. Like Nacmine, most of the subdivided lots in Rosedale have avoided the 1:25 year flood plain. New development of the 1:25 year flood plain should not be allowed. Development beyond the beyond the 1:25 year flood line could be allowed in the subdivision west of Rosebud Creek, provided it is flood proofed to the 1:100 year flood level. Further study is needed to determine the feasibility of flood proofing existing flood plain buildings. Removal of the 8 unoccupied, poor condition dwellings would prevent new people from moving in without flood proofing and would reduce the flood damage potential.

New subdivision and development of Rosedale should continue on the higher land west of Rosebud Creek and south of the Red Deer River. The Aerial flats should be retained for agricultural use. Subdivision for

acreage properties should not be allowed, particularly on the floodway.

7.9 Cambria (including Eladesor)

7.9.1 Land Use

In Cambria, 27 buildings were located on the 1:100 year flood plain, including the 3 dwellings east of the Red Deer River in the former community of Eladesor (appendix G). Seventy-four percent of these were also on the 1:50 year flood plain and 18% were on the 1:25 year flood plain. On the 1:100 year flood plain, there were 26 single family dwellings and one quonset used for storage (Table 7.8). Twenty-four buildings (89%) were built prior to 1940; four of these (16%) were unoccupied. One house was built in the 1960s and one house was built since 1970; it was under construction and unoccupied during this study.

According to the Alberta Department of Municipal Affairs classification, one building was class C and 9 were class E; two of the latter were unoccupied. The majority of dwellings (13) were class F; two of these were unoccupied. There was one quonset. The majority of buildings were in fair (27%), fair to poor (23%) and poor (27%) condition.

Five buildings had a basement water entry point. The remaining 22 had first floors less than 0.5 m above ground level.

In 1978, all of Cambria was zoned for hamlet residential uses (appendix G). There were 31 vacant residential lots on the 1:100 year flood plain.

Table 7.8

CAMBRIA: LAND USE AND BUILDING DESCRIPTION

Variable	occupied buildings	unoccupied buildings	total buildings (number)	(percent)
Land Use[a]				
single family residential	21	5	26	96%
industrial/storage	1	0	1	4%
Building Age[b]				
pre-1940	20	4	24	89%
1960-1969	1	0	1	4%
post 1970	1	1	2	8%
Building Class[b]				
B	0	1	1	4%
C	1	0	1	4%
E	7	2	9	34%
F	13	2	15	57%
quonset	1	0	1	4%
Building Condition[a]				
good	1	1	2	8%
fair to good	4	0	4	15%
fair	6	0	6	22%
fair to poor	5	0	5	19%
poor	6	4	10	37%
Lowest Water Entry Point[a]				
First Floor Only				
0-0.5 meter	19	3	22	81%
Basement/First Floor				
0-0.5/0-0.5 meter	2	0	2	8%
0-0.5/+1.0 meter	1	2	3	12%

Source: a) Field Survey, conducted by the author, September, 1978.
b) Municipal Tax Assessment Forms, August, 1978.

Note: The criteria for each variable are discussed in chapter two (section 2.5).

7.9.2 Alternative Land Use Policies

a) Vacant Undeveloped Land

Within the hamlet of Cambria, two vacant land parcels were owned by the Province of Alberta. North of Cambria, between the railroad and the highway, there were several low-lying parcels that were privately owned, were not used for agriculture and could perhaps be purchased and used for parkland/open space.

b) New Subdivision Applications

Within the hamlet boundaries of Cambria, there were no privately owned land parcels which could be subdivided for development.

c) Vacant Subdivided Lots

In Cambria, there were 27 vacant lots and two unoccupied, abandoned dwellings, making 29 potentially developable lots on the flood plain. In Eladesor, across the River, there were three houses, two of which were unoccupied, and about 28 subdivided lots. North of Cambria, there were 4 unoccupied, subdivided lots. In Cambria, there were only several subdivided lots and two dwellings on the 1:25 year flood plain. Like Nacmine and Rosedale, this may be due, in part to the potential flood hazard and past flooding. Thus, it may be reasonable to restrict further development to the floodway fringe, with flood proofing, in Cambria.

d) Developed Subdivided Lots

All existing development had a water entry point less than 0.5 m above the ground. In the event of a 1:100 year flood, most of the Cambria flood plain would be inundated by 0.5 to 1.0 m of water. Thus, most

homes, with the possible exception of the new dwelling being constructed, would experience flood damages (appendix G). Potential damages could be reduced for the three occupied dwellings with basement water entry points by flood proofing basement windows.

It may be possible to protect development by constructing dykes. However, several homes would probably have to be purchased. Owner opposition can be anticipated if the river view is lost.

Public purchase of the Cambria 1:100 year flood plain would involve almost the entire hamlet (appendix G). Opposition could be anticipated from the population of the entire hamlet. Purchase of the 1:25 year flood plain would involve very little development land; thus, it could be considered as an alternative.

e) Abandoned Buildings

There were four unoccupied flood plain buildings in Cambria. Their removal would reduce the number of flood plain buildings in Cambria by 16%.

7.9.3 Recommendations for Future Land Use Policies

Only several subdivided lots and two dwellings were located on the 1:25 year flood plain in Cambria; however, all of the development in the hamlet was on the 1:100 year flood plain in 1978. It is recommended that Cambria not be protected with dykes. Instead, a two-zone management policy should be adopted by the Improvement District to control new development. New residential development should not be allowed on the 1:25 year flood plain on existing lots. New development could be allowed on subdivided lots on the fringe area, provided it is flood proofed to

the 1:100 year flood level. Further study is required to investigate the feasibility of flood proofing existing buildings. Removal of the five unoccupied, dilapidated buildings would prevent new people from moving in without flood proofing and would reduce the flood damage potential. Public purchase of the 1:25 year flood plain in Cambria could be considered by the municipal government because the area is largely undeveloped and is partially owned by the provincial government. This would prevent future speculation for development of this property.

There are a number of subdivided, vacant lots west of Center Street, which are not on the flood plain (appendix G). If there is a demand for new dwelling lots, these are available and will likely fill foreseeable future demand. Current demand is low, partly because the lots in Cambria are not serviced. New subdivision and development, if it occurs, should be directed away from the flood plain.

7.10 Lehigh

7.10.1 Land Use

In Lehigh, 7 single family dwellings were located on the estimated 1:100 year flood plain (appendix H). Five of the buildings were constructed prior to 1940; two of these were unoccupied. Two new mobile homes have been installed since 1970 (Table 7.9).

According to the Alberta Department of Municipal Affairs classification, two dwellings were class E and one was class F. One of each class was unoccupied. The two new dwellings were mobile homes; both were occupied. Two dwellings were in good condition and the two unoccupied dwellings were in poor condition.

Table 7.9

LEHIGH: LAND USE AND BUILDING DESCRIPTION

Variable	occupied buildings	unoccupied buildings	total buildings (number)	(percent)
Land Use[a]				
single family residential	5	2	7	100%
Building Age[b]				
pre-1940	3	2	5	71%
post 1970	2	0	2	29%
Building Class[b]				
E	2	1	3	43%
F	1	1	2	29%
mobile	2	0	2	29%
Building Condition[a]				
good	2	0	2	29%
fair to good	1	0	1	14%
fair to poor	2	0	2	29%
poor	0	2	2	29%
Lowest Water Entry Point[a]				
First Floor Only				
0-0.5 meter	3	2	5	72%
0.6-1.0 meter	1	0	1	14%
Basement/First Floor				
0-0.5/0.6-1.0 meter	1	0	1	14%

Source: a) Field Survey, conducted by the author, September, 1978.
b) Municipal Tax Assessment Forms, August, 1978.

Note: The criteria for each variable are discussed in chapter two (section 2.5).

Four dwellings had no basements and were less than 0.5 m above ground level. Only one had a basement water entry point and a main floor 0.6 to 1.0 m above ground level. The two mobile homes had first floors between 0.6 and 1.0 m above ground level.

Although Lehigh was subdivided as a residential community during the coal boom and the subdivided lots are still registered, it was zoned for conservation-agricultural use by the I.D. No. 7 Development Control Bylaw (1978). There was no gas or water service in 1978.

7.10.2 Alternative Land Use Policies

a) Vacant Undeveloped Land

Within and adjacent to Lehigh, there was much vacant flood plain which could be publicly purchased or controlled to maintain open space on the flood plain. Most of this was used for agriculture, which is compatable with the flood hazard. Potentially, more restrictive zoning than the conservation-agriculture designation could be used to ensure that intensive flood plain development does not occur.

b) New Subdivision Applications

Lehigh is already subdivided into 50 lots. In fact, in 1948, there were 50 occupied dwellings in Lehigh (Calgary Herald, April 26, 1948). Because these lots already exist, it is unlikely that there will be pressure for new subdivision in Lehigh.

c) Vacant Subdivided Lots

Despite the fact that Lehigh lots are not serviced, except with electricity, two of the five occupied dwellings have been installed on

vacant subdivided lots within the past five years. One older dwelling was occupied by a young family which plans to build a new home in Lehigh. Thus, there may be requests to develop the Lehigh flood plain in the future. Because the flood levels are not known at this time, it is not possible to consider development of the floodway.

d) Developed Subdivided Lots

In Lehigh, 4 dwellings had first floors less than 0.5 m above ground level; two of these were unoccupied. Two dwellings had a first floor between 0.6 and 1.0 m above ground level; one had a basement opening less than 0.5 m above ground level and a first floor 0.6 to 1.0 m above ground level. In the event of a 1:100 year flood, all dwellings would likely receive flood damage. Only one home could be flood proofed to prevent damage from flooding less than 0.5 m deep. Because there were only 5 occupied homes, it would probably be uneconomical to protect this area. Conversation with Lehigh residents indicated that strong opposition to dyke construction and public purchase could be anticipated.

e) Abandoned Buildings

There were two unoccupied dwellings in Lehigh. Their removal would reduce the number of flood plain buildings from 7 to 5 and prevent new occupants from moving into these dwellings without flood proofing.

7.10.3 Recommendations for Future Land Use Policies

Because there are only five occupied dwellings on the Lehigh flood plain, it is recommended that these buildings not be protected with a dyke. Depending upon the location of the 1:25 year flood plain, it is

recommended that further development on the 1:25 year flood plain not be allowed and that new development be allowed only in the fringe area, with flood proofing. Since there has been some development in Lehigh in recent years, more can be anticipated in the near future. The Improvement District should control new development so that it does not increase the flood hazard. Indeed, public purchase of the 1:25 year flood plain in the vicinity of Lehigh could be considered as a measure to control speculation for future development of this area.

7.11 East Coulee (including Western Monarch)

7.11.1 Land Use

In East Coulee, including the squatter community of Western Monarch, 62 dwellings were located on the estimated 1:100 year flood plain (appendix H). All were single family dwellings; 14 were squatters (Table 7.10). Twelve squatters were on provincial government property and two, in Western Monarch, were on property owned by the Atlas Coal Mine. Fifty-seven buildings (92%) were built prior to 1940; 23 (40%) of these were unoccupied. Five buildings (10%) had been built since 1970; all of these were occupied. It has been suggested (Fenwick 1979c) and verified by conversation with several East Coulee residents, that some of the dwellings are actually cottages, or second homes. However, this information is rarely recorded on the tax assessment cards. Interviews with East Coulee residents would be necessary to obtain this type of information.

According to the Alberta Department of Municipal Affairs classification, 5 dwellings were class C and D; all of these were occupied. The majority of buildings were class E (34); 14 of these (41%) were

Table 7.10

EAST COULEE: LAND USE AND BUILDING DESCRIPTION

Variable	occupied buildings	unoccupied buildings	total buildings (number)	(percent)
Land Use[a]				
single family residential	29	19	48	77%
squatter	10	4	14	23%
Building Age[b]				
pre-1940	34	23	57	92%
post 1970	5	0	5	8%
Building Class[b]				
C	2	0	2	3%
D	3	0	3	5%
E	20	14	34	55%
F	12	9	21	34%
mobile	2	0	2	3%
Building Condition[a]				
good	7	0	7	11%
fair to good	1	0	1	2%
fair	6	0	6	10%
fair to poor	3	1	4	6%
poor	22	22	44	71%
Lowest Water Entry Point[a]				
First Floor Only				
0-0.5 meter	31	21	52	84%
0.6-1.0 meter	1	1	2	3%
Basement/First Floor				
0-0.5/0-0.5 meter	1	0	1	2%
0-0.5/0.6-1.0 meter	6	1	7	11%
0-0.5/+1.0 meter	1	0	1	2%

Source: a) Field Survey, conducted by the author, September, 1978.
b) Municipal Tax Assessment Forms, August, 1978.

Note: The criteria for each variable are discussed in chapter two (section 2.5).

unoccupied. Twelve dwellings were class F; 9 of these (75%) were unoccupied. Finally, two mobile homes were located on the East Coulee flood plain. The majority of flood plain dwellings (71%) were in poor condition; half of these were unoccupied.

Fifteen percent of the homes had a basement water entry point. The majority of these (11) had a basement opening less than 0.5 m above the ground and a first floor 0.6 to 1.0 m above the ground. Eighty-seven percent of the dwellings had no basement water entry point. The majority of these (52) had first floors less than 0.5 m above ground level. However, 21 of these were unoccupied.

All of the East Coulee 1:100 year flood plain was zoned for residential use, except for the squatters in the conservation-agriculture district in 1978 (appendix H). Fifty-six of the subdivided lots on the estimated flood plain were vacant.

7.11.2 Alternative Land Use Policies

a) Vacant Undeveloped Land

There were no vacant unsubdivided land parcels within the hamlet of East Coulee on the flood plain which could be purchased or where development could be managed in a manner compatable with the flood hazard.

b) New Subdivision Applications

All of the land within the East Coulee hamlet boundaries has been subdivided, except for those parcels occupied by squatters. The Alberta Department of Municipal Affairs has prepared a subdivision plan for the land inhabited by squatters north of the river in East Coulee (appendix H). This application was refused by the CRPC in 1977 for a variety of

reasons, including the potential flood hazard, sewage disposal and lot size. There has been no recent application for subdivision of the area known as Western Monarch, where squatters are living on property owned by the Atlas Coal Mine Company.

c) Vacant Subdivided Lots

On the East Coulee estimated flood plain, there were 56 vacant subdivided lots and 19 unoccupied houses on subdivided lots. There is little development pressure in East Coulee because there are few employment opportunities and because the lots are not serviced. Only 5 dwellings have been built in the past decade. Since about 70% of the flood plain lots were vacant or contained abandoned buildings in 1978, it may be worthwhile considering disallowing further development on the estimated 1:100 year flood plain, or perhaps another recurrence interval flood plain, when this information is available. If this area is protected, further development could continue, especially if water and gas servicing are available in the future. Public purchase of these vacant lots would prevent speculative buying and maintain open space on the East Coulee flood plain.

d) Developed Subdivided Lots

Only one occupied dwelling has its lowest potential water entry point higher than 0.5 m above ground level. Seven buildings could benefit from flood proofing. But, the majority of occupied buildings would be inundated at the first floor level by 0.5 m of water. Small dykes were built along the river bank in East Coulee, most likely following the 1940s floods. They have not been maintained and it is not known how much pro-

tection they would provide in the event of overbank flow, since there have been no recent floods.

Public purchase of existing development could be considered. This would involve 29 occupied dwellings on subdivided lots and 10 occupied squatters' dwellings on land owned by the provincial government or the Atlas Coal Mine Company. The province could consider a program of gradually purchasing lots or houses as they come for sale to prevent them from being purchased by speculators who anticipate that the lots may be serviced and that future development will occur in East Coulee.

e) Abandoned Buildings

There were 23 unoccupied dwellings in East Coulee. It has been suggested that some of these may be summer cottages. However, if there were visible signs of recent occupation, dwellings were included as occupied. Removal of abandoned buildings on the East Coulee flood plain would reduce, by about 37%, the number of buildings that would be adversely affected by flooding.

7.11.3 Recommendations for Future Land Use Policies

It is recommended that new development of the East Coulee flood plain not be allowed, since there is a high proportion of unoccupied dwellings and vacant lots in this area. Public purchase of this land could be considered to prevent future speculation by entrepeneurs. The lots are not serviced at the present by any utilities except electricity; thus, the current land value is fairly low. Future development should be directed to the higher ground surrounding the small commercial area (appendix H).

Squatters living on the 1:25 year flood plain should not be given title to the land. This land would then revert to open space, after the squatters leave. Finally, before a policy for flood plain management is adopted for East Coulee, a study should be undertaken to determine the number of second homes and cottages on the East Coulee flood plain and the frequency of occupation of these dwellings.

7.12 Rural

7.12.1 Land Use

Rural areas between the urban settlements are sparsely populated in the Drumheller Valley. Because the flood plain maps were not complete when this thesis was written, it was assumed that the 1:100 year flood plain includes the area between the Dinasour Trail and the Red Deer River (appendix B). In this area, there were 8 farmsteads, that is, homes and storage facilities associated with agricultural operations. There were 8 rural residences or acreages and 3 unoccupied houses (Table 7.11). There were two market garden operations and one golf course.

The Dinasaur Golf and Country Club was located north of Midlandvale, east of the Red Deer River. The club house and proshop were built on the flood plain in 1968; the dwelling was moved to the property in the same year. Further south, there were two acreage properties, which were classified as farmsteads because they had associated barns, chicken coops and so forth. The surrounding land was used for pasture or cultivated. Closer to Midlandvale, there were three old dwellings which were in fair to poor condition. Only two of these were on the flood plain. The intervening badlands were used for grazing cattle. In this area, the property that was owned by the Midland Mine has been donated to the

Table 7.11

RURAL: LAND USE AND BUILDING DESCRIPTION

Variable	occupied buildings	unoccupied buildings	total buildings (number)	(percent)
Land Use[a]				
farmstead	8	0	8	35%
non-farm residential	8	3	11	50%
commercial - market garden	2	0	2	9%
- golf course	1	0	1	5%
Building Age[b]				
pre-1940	9	3	12	54%
1950-1959	3	0	3	14%
1960-1969	2	0	2	9%
post 1970	5	0	5	23%
Building Class[b]				
C	7	0	7	32%
D	7	0	7	32%
E	4	1	5	22%
F	1	2	3	14%
Building Condition[a]				
good	10	0	10	45%
fair to good	2	0	2	9%
fair	4	1	5	23%
fair to poor	2	0	2	9%
poor	1	2	3	14%
Lowest Water Entry Point[a]				
First Floor Only				
0-0.5 meter	9	3	12	54%
0.6-1.0 meter	1	0	1	5%
Basement/First Floor				
0-0.5/0-0.5 meter	3	0	3	14%
0-0.5/0.6-1.0 meter	6	0	6	27%

Source: a) Field Survey, conducted by the author, September, 1978.
b) Municipal Tax Assessment Forms, August, 1978.

Note: The criteria for each variable are discussed in chapter two (section 2.5).

provincial government for a provincial park. This development is presently in the preliminary planning stages (Irwin 1979).

On the south side of the river, between Nacmine and Newcastle, there was the community of Kneehill, which is not on the flood plain. The 9 dwellings belong to squatters; the property was owned by the federal government in 1978.

Between Drumheller and Rosedale, most of the flood plain was undeveloped, except where it widens out close to Rosedale (appendix B). Here, there were three rural non-farm residence, one commercial market garden and one farmstead. All of the houses have been built in the past 20 years.

On the flats between Rosedale and Cambria, there was one farmstead, in 1978. The original farmhouse was unoccupied.

East of the Red Deer River, adjacent to Cambria, an old railroad station has been converted into a dwelling. This may be a seasonal residence. Between this and Lehigh, most of the flood plain was used for agriculture: grain crops, grazing and a market garden (appendix B). There were three farmsteads, several rural non-farm dwellings and one unoccupied dwelling. The settlement of Willow Creek was in this area; the subdivision plans are still on record at the Alberta Department of Municipal Affairs, but it is not classified as a hamlet. The community of Willow Creek no longer exists; however, in 1971 and 1973, two land parcels were surveyed and subdivided in Willow Creek. North of Lehigh, the flood plain was used for grazing in 1978.

7.12.2 Alternative Land Use Policies

a) Vacant Undeveloped Land

Public purchase of the rural portion of the Drumheller Valley flood plain would probably result in considerable public opposition. Because most land uses are agricultural, recreational or open space, which are suitable flood plain uses, it may be possible to adopt municipal policies or development control regulations to ensure that these types of land uses are maintained, without public purchase.

b) New Subdivision Applications

The Drumheller Valley rural population is not growing and there has been little pressure to subdivide rural land parcels. However, there have been applications for non-farm residential acreage subdivisions. In the past decade, five rural non-farm residences have been built; this represents about one-quarter of the rural development. Future applications for acreage development may be anticipated. A policy to keep the acreage dwellings away from flood-prone areas should be considered. In rural areas, where there is still much open space, the PRPC could reasonably require a broad flood plain, perhaps the 1:25 year flood plain, as environmental reserve or place a restricted development caveat on this land when approving future subdivision in the rural area. Public opposition would probably not be very significant, because most recent subdivisions have been for acreages, not intensive housing projects.

c) Vacant Subdivided Lots

As discussed above, the settlement of Willow Creek was located between Cambria and Lehigh. Since the land has been subdivided and the

plans are still registered, future development of this flood plain community will be managed by the I.D. No. 7 Administration. The PRPC may have no control over future development in this subdivided area.

d) Developed Subdivided Lots

Existing flood plain development was spread out along the valley floor in 1978. None of the buildings were visibly flood proofed. However, 7 dwellings could be protected to the 1:100 year flood level by flood proofing basement water entry points. Because rural development is not concentrated in a single area, flood protection would likely be very costly and would encourage applications for subdivision and development behind the dykes.

e) Abandoned Buildings

There were three abandoned rural dwellings on the rural flood plain. All three have been replaced by more modern dwellings on the same property. The Alberta Department of Municipal Affairs could require these buildings to be removed.

7.12.3 Recommendations for Future Land Use Policies

A land use management policy, based on a two-zone flood plain should be adopted for the rural portion of the Drumheller Valley to prevent future intensive flood plain development in new areas. If a floodway, where new development would not be allowed, is defined by the I.D. No. 7 Administration, development could be directed away from this area. Most of the rural flood plain land was owned by farmers or ranchers

in 1978, not speculating developers. Increased use of the flood plain for market gardening and other agricultural pursuits should be encouraged. Wider use of crop insurance would reduce the risk involved in agricultural use of flood plain.

If new subdivision for acreage properties is allowed, dwellings and other buildings should not be allowed on the floodway, but should be allowed on the floodway fringe, with flood proofing. This could be ensured by the PRPC, if the 1:25 year flood plain is required as environmental reserve from all new rural subdivisions.

The existing rural development should not be protected by dykes because it is spread out along the Valley. However, most of the buildings could be protected to some degree by flood proofing basement windows and other openings.

7.13 Discussion

In this chapter, the land use characteristics of the ten Drumheller Valley communities have been described and alternative flood plain management policies have been discussed. A management policy has been suggested for each community, to meet the four goals defined by the author in section 7.1. Briefly, these were: to maximize flood compatable utilization, to minimize community disruption, to share the cost for protection between those protected and the government, and to use the environmental reserve to create flood plain open space in new subdivisions.

Different flood plain management policies have been recommended for the City of Drumheller and I.D. No. 7 flood plains because the flood plain has been developed differently in the two municipalities. In the City, most of the flood plain land has been subdivided and is developed

with both new and older buildings. In the Improvement District, rural flood plain land has rarely been subdivided and in the hamlets, subdivision of the 1:25 year flood plain appears to have been avoided. In the hamlets, buildings are older, in poorer condition and unoccupied more frequently.

For the City of Drumheller, it is recommended that existing communities be protected by low dykes in conjunction with a program of flood proofing for new and existing development. New, controlled development should be allowed on subdivided lots on the flood plain behind the dykes to ensure that existing communities do not deteriorate. New development should be flood proofed to ensure that damages do not occur if the dykes are overtopped. New subdivision should not be allowed behind the dykes; the dykes should be situated to maximize the amount of open space between the dykes and the river and to place the dykes on public property as much as possible. New subdivision and development, particularly for residential purposes, should not be allowed behind the dykes in the City of Drumheller communities.

In the Improvement District, flood plain management should be based on a two-zone flood plain. New subdivision and development for commercial and residential uses should not be allowed on the inner zone or floodway, while new flood proofed development could be allowed in the fringe area. The floodway should be required as environmental reserve from all new subdivisions. The provincial government should investigate a policy of partially compensating the owner for this property. Even if land is annexed to the City of Drumheller, this policy should be maintained to ensure that new subdivision of the floodway does not occur and that future dyking will not be needed to protect new subdivisions in

the future.

Because development in the hamlets has, for the most part, avoided the floodway, the hamlets should not be protected by dykes. Taking into account future protection by the Red Deer Dam, the number of buildings that would require protection would be low. Also, in the hamlets, most of the buildings were built before 1940 and are in fair to poor condition. These will probably be replaced gradually by new development which should be flood proofed. Further study is needed to determine the feasibility of flood proofing existing buildings in the hamlets. Public purchase of flood plain land in the hamlets could be undertaken gradually, if property comes for sale to prevent speculation and to ensure the riverside parkland for the General Plan.

Both the City and Improvement District should adopt a policy to allow zoning of the flood plain to be changed by the municipality following a flood. This should be coordinated with the Alberta Disaster Services program so that compensation will not be provided by the provincial government for flood victims to rebuild on the flood plain following a major disaster. Some aid should be provided for victims to move away from the hazard area. Then, the flood plain could be rezoned for less intensive uses.

Before flood plain land use management will become operational in the Drumheller Valley, the provincial and municipal governments must agree upon a policy for the squatters. The majority of the squatters in the Valley live on the flood plain, many on the floodway. Such a policy would determine whether the squatters would be given title to the land, which would mean that this land should be protected, or whether it will be left to revert to open space or less intensive uses when the squatters

leave. The provincial government should consider providing financial incentives to encourage squatters to move to higher ground, rather than protecting them with dykes.

Dilapidated, unoccupied buildings in the Drumheller Valley are not only unsightly, but they also increase the potential damages from flooding. Floating debris may cause damage to other flood plain buildings during a flood. Moreover, if these buildings are removed, new owners would not be able to move in, renovate the buildings and inhabit them without flood proofing.

There is not a high demand for new housing or commercial development because the Drumheller Valley population is not growing rapidly. In fact, in the two subdivisions that have been developed by developers on and adjacent to the flood plain in Midlandvale and Newcastle, half of the new homes were unoccupied at the time of this study, although they had been constructed for over one year. Thus, new development should be directed towards vacant lots in existing subdivisions and to new subdivisions that are not on the flood plain. During the past 8 years, new development has occurred on the flood plain at an average rate of 20 buildings per annum. It should be possible to meet this low level of demand in non-flood plain areas in the future.

Thus, a flood plain management strategy has been suggested for the Drumheller Valley. By protecting existing communities with low dykes in the City of Drumheller, in conjunction with a flood proofing program, and by discouraging new development of the floodway in I.D. No. 7, the two municipalities should be able to ensure that potential flood damages do not increase. In order to implement such a program, cooperation between the municipalities, regional planning commission, the Alberta

Department of the Environment and Alberta Disaster Services is necessary to ensure that policies and decisions concerning emergency action, public relief, new development and existing development are made in a consistent manner.

CHAPTER VIII

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

8.1 Summary

In this thesis, alternative flood plain land use management policies and associated adjustments to reduce the Drumheller Valley flood hazard were suggested and discussed for each of the ten Drumheller Valley communities. Policy recommendations were made for each community to meet four management goals defined by the author. The alternatives were based on information derived from flood plain literature, reports of present Alberta and Drumheller Valley flood plain management and flood adjustment policies and programs, a review of Alberta legislation and municipal bylaws affecting Drumheller Valley flood plain management, and a land use study of the Drumheller Valley flood plain, which was based on information recorded on the 1977 municipal tax assessment forms and a field study conducted by the author in the fall of 1978. Maps of land use, land use zoning, building classification and lowest water entry point were prepared for each community; data pertaining to building use, age, classification, condition and lowest water entry point were tabulated for each community. Throughout the course of the study, discussions were held with PRPC and CRPC planning staff, Alberta Department of Environment planners, engineers and consultants, and City of Drumheller and I.D. No. 7 staff. The review of legislation and bylaws, the land use study and discussion of alternatives were prepared for the Alberta Department of Environment, Planning Division and make up the "land uses and regulations" component of the eight-component Drum-

heller Flood Control Study.

A broad range of alternative flood hazard adjustments was identified and discussed in the third chapter, using the "range of choice" framework developed in the natural hazards research. Literature related to each of the alternative adjustments was reviewed. It was found that in most regions, no single adjustment will solve a flooding problem; rather, a mix of adjustments, including both structural and nonstructural measures is frequently required to reduce potential flood damages.

The history of flooding in the Drumheller Valley, and present and past adjustments to the flood hazard were examined in the fourth chapter. Although at least fourteen floods have occurred since the valley was first settled in the early 1900s, only several of these events were recorded. The Red Deer River has not flooded in the Drumheller Valley since 1954, when a flood of about the 1:25 year magnitude is estimated to have occurred. During the past 25 years, there has not even been a 1:10 year event. Thus, many people are probably not aware of the potential hazard. However, the level of hazard awareness has not been documented in the Drumheller Valley. In the past, emergency action, evacuation and relief were used to cope with damages from flood waters. Existing adjustments, with the exception of some flood proofing installed by residents following the 1950s floods, have been initiated by the Alberta government or through federal-provincial cost-sharing programs. These include: flood forecasting, emergency preparedness, public relief, crop insurance, flood control, and flood proofing and land use management. In the future, the Red Deer Dam may offer some flood protection, which may be augmented by local flood control measures, pending on the findings of the Drumheller Flood Control Study.

Alberta legislation and municipal bylaws affecting Drumheller Valley land use were reviewed in chapter five, in order to establish the legal framework within which a flood plain land use policy could be formulated. Alberta is presently negotiating an agreement with the federal government under the National Flood Damage Reduction Program. This national program and possible effects on the Drumheller Valley land use policy were discussed briefly. Alberta statutes allow the Alberta Department of the Environment or the municipal governments to purchase flood plain property and/or regulate land use; however, neither has been undertaken in the Drumheller Valley. In this area, and most of Alberta, flood plain land uses are regulated by the municipal government. It was found that the policies for managing flood plain land in the City of Drumheller and I.D. No. 7 were unclear because there were discrepancies between the municipal development control bylaws and the Drumheller Valley General Plan (1977). These inconsistencies were discussed and the need for a clear, flood plain management policy based on a legal definition of the flood plain was recognized.

Existing Drumheller Valley flood plain land use policies were discussed in chapter six. Alternative means for developing flood plain land use policies were suggested for five general categories of land: undeveloped vacant land, new subdivision applications, vacant subdivided lots, developed subdivided lots and abandoned buildings. Then, general social, economic and environmental effects of alternative land use policies were suggested for these categories. It was found that, with no changes in the existing legislation, it is possible to manage future Drumheller Valley flood plain development. However, municipal commitment and cooperation between the municipalities, regional planning com-

mission and the Alberta Department of the Environment are necessary to ensure that a flood plain management policy is applied consistently.

In chapter seven, the land use and building characteristics of the ten Drumheller Valley communities were described, the potential effects of adopting the alternative land use policies outlined in chapter six were discussed for each community and general recommendations for future land use policies were made. It was found that flood plain development was primarily in the form of single family dwellings. Sixty-eight percent of the development was in the urban communities; twenty-nine percent was in the hamlets and three percent was rural. Since flood plain uses differed from one community to another, it was found that the land use policy recommendations must be site-specific, with various combinations of alternatives for each community. It was recommended that different policies be adopted in the City of Drumheller and I.D. No. 7. Because a high proportion of Midlandvale, Newcastle and North Drumheller was located on the 1:25 year flood plain and because Drumheller flood plain development was well-established, it was recommended that these communities be protected by a low dyke, in conjunction with a program to flood proof development behind the dyke. All new development on the flood plain behind the dyke should be subject to approval by the municipality. It was recommended that the 1:25 year flood plain in I.D. No. 7 be retained as a floodway and that hamlet and rural development not be protected by a dyke because, with the exception of the squatters, development in these communities has, for the most part, avoided the 1:25 year flood plain.

8.2 Conclusions

As a result of this study, four conclusions have been drawn about the available adjustments to the flood hazard in Alberta and the Drumheller Valley. These are summarized below.

First, existing Alberta government programs provide for flood forecasting, emergency action, emergency relief and the framework for municipal flood plain management in the Drumheller Valley. Moreover, the Alberta Department of the Environment, Planning Division is currently evaluating flood protection alternatives for the Drumheller Valley in the Drumheller Flood Control Study. The effectiveness of these programs has not been tested because the Red Deer River has not flooded since they have been inaugerated. These programs have all been initiated by the provincial government; however, there is little coordination among the programs, either at the provincial or municipal level. Indeed, these adjustments, even including those covered in the Drumheller Flood Control Study, do not cover the full range of structural and nonstructural adjustments outlined in chapter three. The full range of adjustments should be studied for each Drumheller Valley community.

Second, in Alberta, decisions about the use of land, including a designated flood plain, are made by the municipal government. New subdivisions must be approved by the regional planning commission. Advice may be provided by the Alberta Department of the Environment, but the decision is made by the regional planning commission; Alberta Department of the Environment cannot disallow a flood plain subdivision. All development of subdivided land is controlled by the municipal government. Thus, despite the fact that the provincial government funds flood forecasting, emergency preparation and relief programs and will fund future

flood protection works, the provincial government has very little direct control over the rate and type of new flood plain development in the province.

Third, existing Alberta government legislation allows for more specific flood plain management and development policies than those that exist presently in the Drumheller Valley. Moreover, at present, the development control bylaw and general plan bylaw are inconsistent with regards to flood plain development policies. Interpretation of these conflicting documents causes confusion for both developers and administrators. Since the municipalities have limited experience in this area, it is concluded that provincial assistance, through measures such as developing policy statements and providing a legal definition of the flood plain would guide the regional planning commissions and municipal governments in the creation of policies for flood plain land use and in making consistent development decisions.

Fourth, it was concluded that a flood plain policy, combining protective works with flood proofing for intensively developed urban communities and restricting 1:25 year flood plain development in the I.D. No. 7 hamlets and rural areas would minimize future flood damages in the Drumheller Valley. New subdivision and development for residential and commercial uses should be approved in unprotected areas according to a two-zone flood plain. The inner zone should be required by the PRPC as environmental reserve; subdivision with flood proofed development should be allowed in the outer zone. Thus, prior to submitting a subdivision application, the developer would be aware of the developable area. This is in contrast to the existing policy whereby a subdivision application is made, and then the developer is told what land he can and

and cannot develop on the basis of backwater flooding computations. If such a flood plain management policy, which combines structural and non-structural adjustments is coordinated with the existing flow forecasting, emergency preparedness and relief programs, potential flood damages in the Drumheller Valley could be minimized.

8.3 Recommendations for Management and Future Study

8.3.1 Management Recommendations

Recommendations for future flood plain management in the Drumheller Valley and in Alberta are made below. Although these result from this study of the Drumheller Valley, they may apply in varying degrees to other flood plain communities in Alberta.

First, the sections of the development control bylaws and the General Plan Bylaw for the City of Drumheller and I.D. No. 7 should have consistent policies for the management of future flood plain development. This would prevent confusion on the part of developers and officials interpreting these conflicting documents.

Second, once a consistent flood plain management policy has been adopted by the City of Drumheller and I.D. No. 7 as part of the bylaw, specific flood plain land use districts or zones should be designated by both municipalities.

Third, in the City of Drumheller, all new flood plain development, including single family dwellings, should be approved by the municipality. Even if new development is in area that would be protected with dykes, municipal approval would ensure that the development does not increase the flood hazard.

Fourth, a new municipal flood plain management policy should be flexible enough to allow rezoning of the flood plain and public purchase of severely damaged or destroyed property following a flood. If such a policy is adopted by the municipalities, only limited assistance should be provided by the provincial government for rebuilding in the flood hazard area, following flood damage. Instead, the government should investigate the possibility of providing financial incentives to encourage those experiencing severe damage to move out of the hazard area.

Fifth, a public education program about the location of the flood plain and the new flood plain management policy should be undertaken in the Drumheller Valley and other flood-prone areas of Alberta to increase public awareness of the hazard and the protective measures and emergency procedures available. There is need for recognition that the 1:100 year flood, for example, can be exceeded. Protection to this, or any other arbitrary level, is not complete protection; very costly damages may result if this level is exceeded. This is especially true in areas, such as the Drumheller Valley, where streamflow records are deficient. Moreover, minor climatic, land use or other changes may result in a series of damaging floods. Flood plain occupants should be aware that even if protection is provided, they should still be prepared to act if a flood event occurs.

Sixth, Alberta government departments and the municipalities responsible for various flood hazard adjustments should agree on a definition of the flood plain which could be valid for appeals and would be consistent for all government programs. In this regard, use of a two-zone flood plain should be evaluated, especially for new subdivision and development.

Seventh, all Alberta programs relating to flood damage reduction and relief for flood damages should be more fully coordinated. This should be undertaken at both the provincial level and the level of the municipalities, such as the City of Drumheller and I.D. No. 7, which are primarily affected by these programs. Coordination is presently left to the municipalities, but to facilitate this, each of the provincial government departments should be aware of the roles and responsibilities of the other departments involved. Conversations with Alberta government officials at Alberta Disaster Services and in the Alberta Department of the Environment indicated that such awareness is lacking at the present time.

Eighth, there is a need for consideration of a broader range of alternatives at both the provincial and municipal government levels. These could include flood insurance, tax adjustments, coordination of existing programs and broader application of flood plain land use management controls and flood proofing. In this context, there is a need to recognize the broad range of opportunities in each of these alternative adjustments. For example, a range of alternative policies has been discussed for flood plain land use management in this thesis. There is similar potential for flood proofing, as has been shown by James F. MacLaren Limited (1978) and for the variety of other adjustments in the range of choice.

8.3.2 Recommendations for Future Study

As research for this thesis progressed, it became apparent that there is a need for more research related to the flood hazard in the Drumheller Valley and in Alberta, in general. Several recommendations

for future research are outlined below.

First, a questionnaire should be administered to flood plain occupants and landowners in the Drumheller Valley to determine the awareness of the flood hazard, existing preparation for flooding, the willingness of people to adopt individual measures and the public acceptability of alternative land use policies and flood control measures. Such a questionnaire should be based upon a sound review of the problem and alternative solutions. This has not been done as part of the Drumheller Flood Control Study. The usefulness of questionnaires in collecting information for urban flood control planning has been well-documented by James (1974).

Second, a program to monitor the effectiveness of the land use policies, flood control measures and other adjustments adopted by the provincial and municipal governments should be undertaken after they have been adopted and are functioning. Indeed, their effectiveness during a flood event should be monitored so that changes can be made to the program by provincial and municipal authorities, if any weaknesses are identified during a flood event.

Third, a study of the managers of different provincial and municipal agencies responsible for the flood damage reduction programs should be undertaken. Several methodologies for this type of research have been tested (MacIvor 1970; Sewell 1971; Simms and Baumann 1976). Documentation of the perceived role of the managers and their awareness of other agencies programs would allow for changes to be made in order to ensure better coordination of these programs in the event of a flood.

Fourth, a study of local flooding from Michichi, Kneehill and Rosebud Creeks should be undertaken in conjunction with a study of the Drum-

heller Valley water balance. The flood plain study and maps prepared by the Alberta Department of the Environment for the Drumheller Valley have concentrated on flooding from the Red Deer River. The flood plain was designated by combining peak flows from the tributary creeks and the Red Deer River. Because flooding of the tributary creeks has occurred when the Red Deer River has not flooded in the past, a study of the local balance would provide a better understanding of local conditions and a stronger basis for predicting local flooding.

Fifth, it is recommended that a study of the feasibility of subsidized flood insurance for existing flood plain development be undertaken for urban municipalities in Alberta. In the event of a flood, the Alberta government frequently provides flood relief to flood victims. It has been shown in the United States that mandatory flood insurance for flood plain occupants ensures that they are aware of the flood hazard and that they are responsible for anticipating and paying at least part of the cost of flood damages. Such a program should be investigated for the Alberta situation.

In this thesis, the adjustments to the flood hazard in the Drumheller Valley have been investigated. Although the discussion of alternative policies has been focussed, for the most part, on land use adjustments, it is recognized that other adjustments are also important and recommendations for future management and research in these areas have been made. Management of flood plain land uses is not sufficient to eliminate flood damages in the Drumheller Valley or any other flood-prone area. However, in conjunction with the existing warning system, disaster preparedness program, proposed protective works and potential associated measures, such as flood insurance, tax adjustments and

public education, a clear flood plain land use policy can be used to limit and control new subdivision and development of unprotected areas and prevent intensive development in protected areas that could be damaged by floods exceeding design capacity. There is an urgent need for additional research about the flood hazard and the range and role of existing and potential adjustments, which will lead to constructive changes in the flood management policy and greater coordination of provincial and municipal programs to reduce flood losses in Alberta.

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APPENDIX A

FIELD SHEET

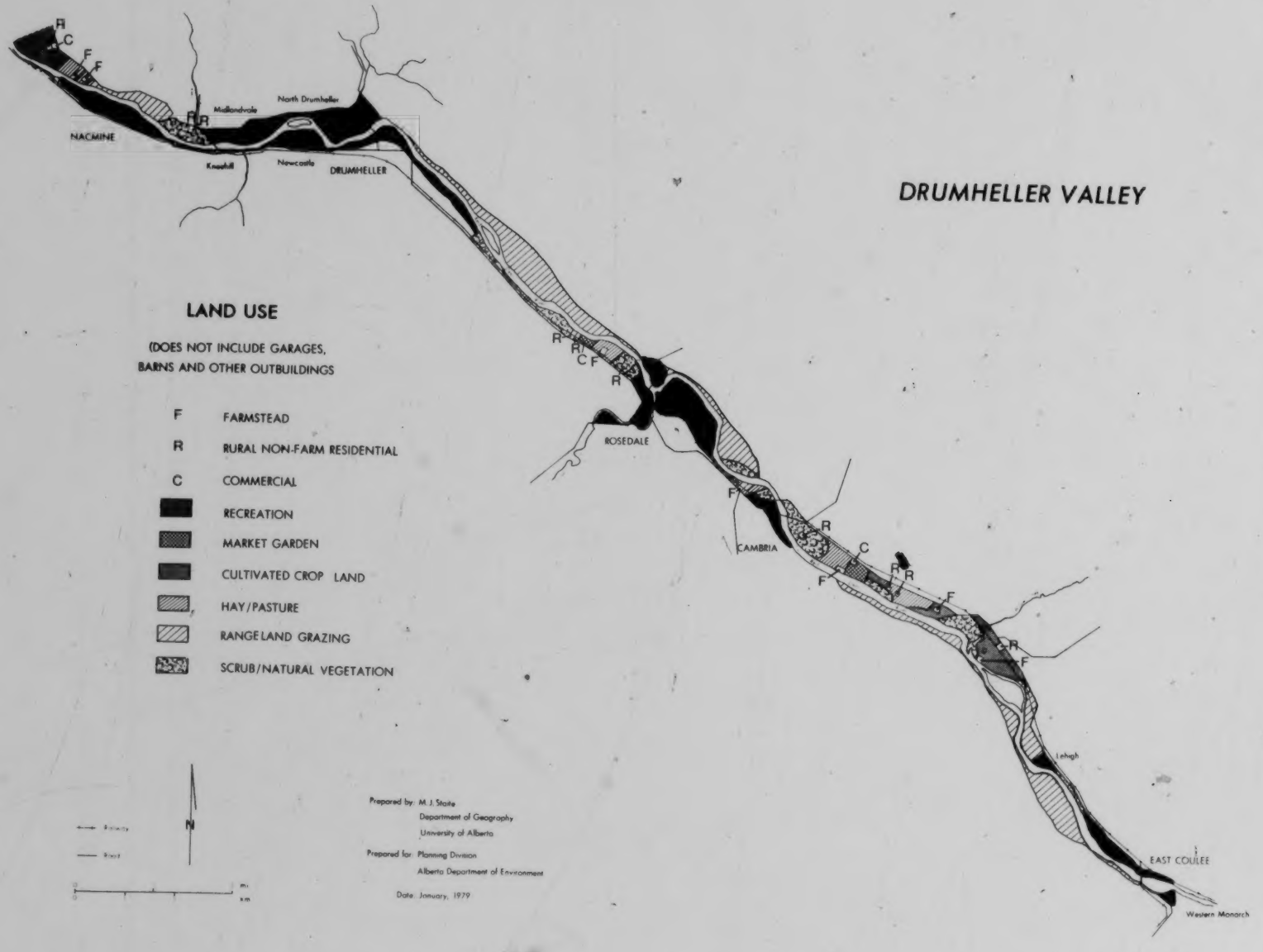
DRUMHELLER FLOODPLAIN LAND USE STUDY

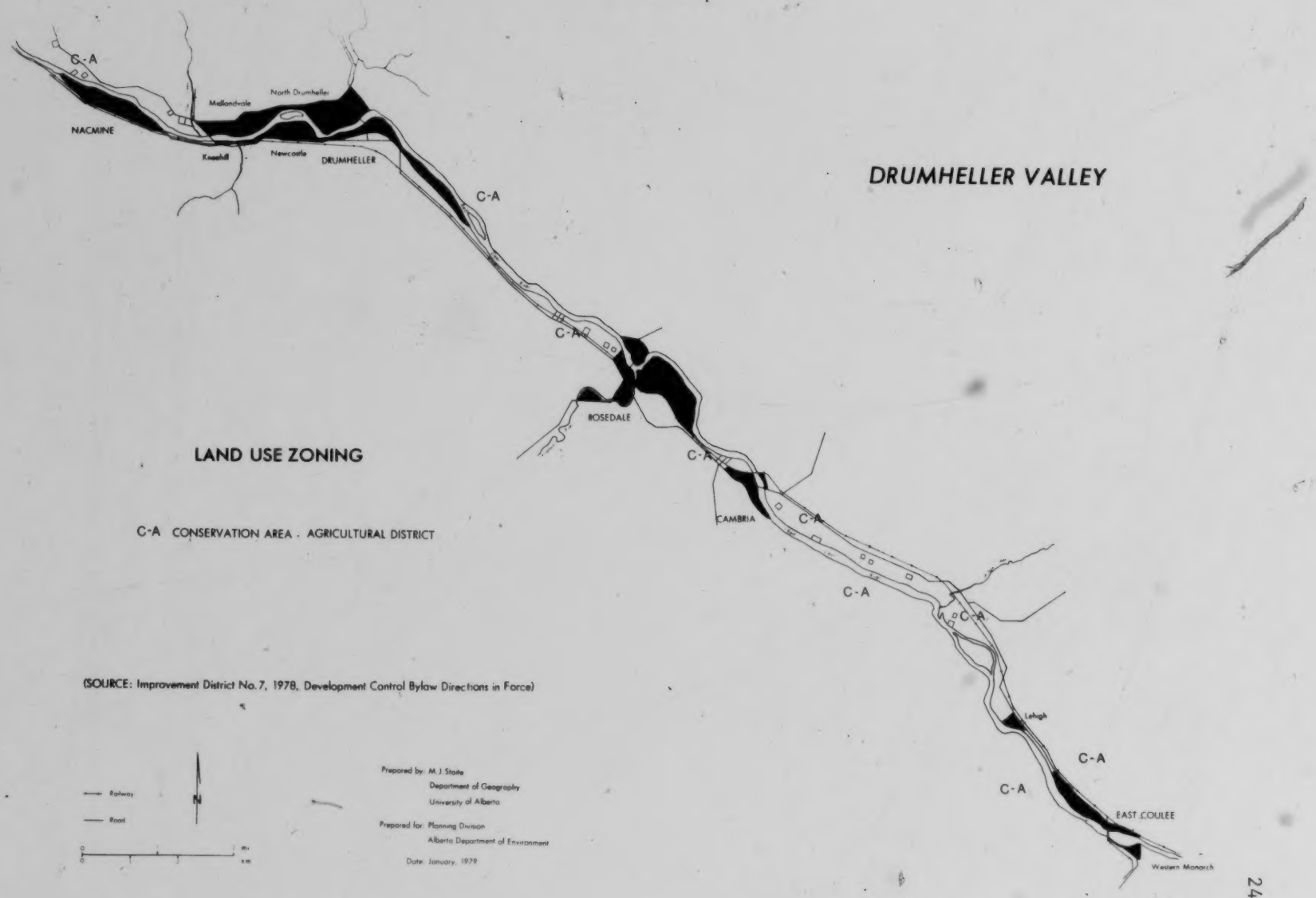
PLAN:_____ BLOCK:_____ SURVEY DATE:_____

Lot	Owner	Address	Year Built	Use	Type	Class	Size	Condition	Structure				Basement						Utilities							Lowest Water Entry Point	First Floor Height	Tax Assessment	Comments
									Frame	Veneer	Masonary	Other	Full	Part	Dugout	Finished	Furnace		Electricity	Water	Gas	San. sewer	Strm. sewer	Sept. tank					

APPENDIX B

DRUMHELLER VALLEY LAND USE MAPS


DRUMHELLER VALLEY
LAND USE
(DOES NOT INCLUDE GARAGES, BARNS AND OTHER OUTBUILDINGS
F FARMSTEAD
R RURAL NON-FARM RESIDENTIAL
C COMMERCIAL
RECREATION
MARKET GARDEN
CULTIVATED CROP LAND
HAY/PASTURE
RANGELAND GRAZING
SCRUB/NATURAL VEGETATION
NACMINE
Midlandvale
North Drumheller
Knockhill
Newcastle
DRUMHELLER
ROSEDALE
CAMBRIA
Lehigh
EAST COULEE
Western Monarch
N
Prepared by: M. J. Staite
Department of Geography
University of Alberta
Prepared for: Planning Division
Alberta Department of Environment
Date: January, 1979



LAND USE ZONING

C-A CONSERVATION AREA . AGRICULTURAL DISTRICT

(SOURCE: Improvement District No. 7, 1978, Development Control Bylaw Directions in Force)

Railway

Road

N

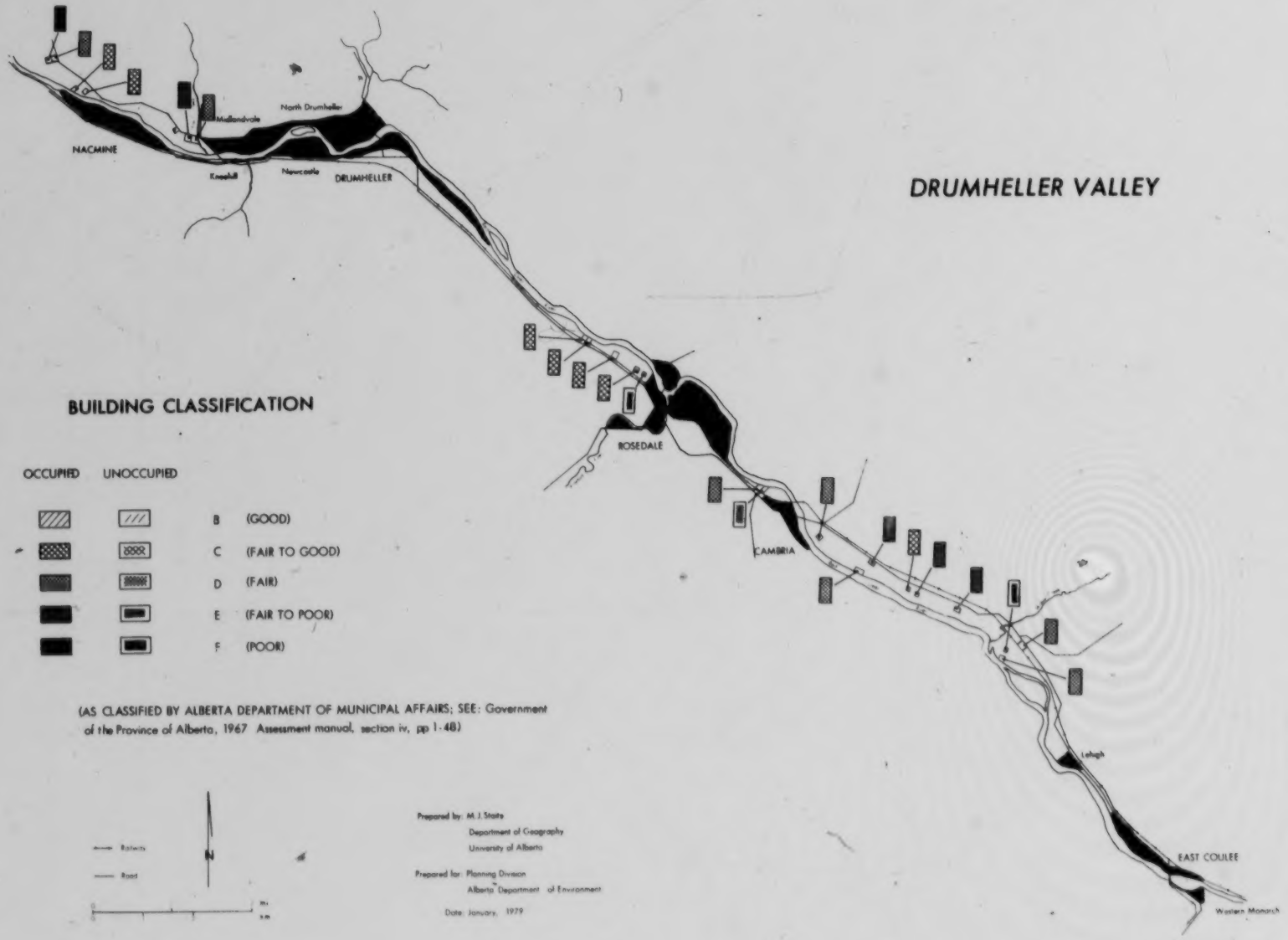
0 1 2 3 mi

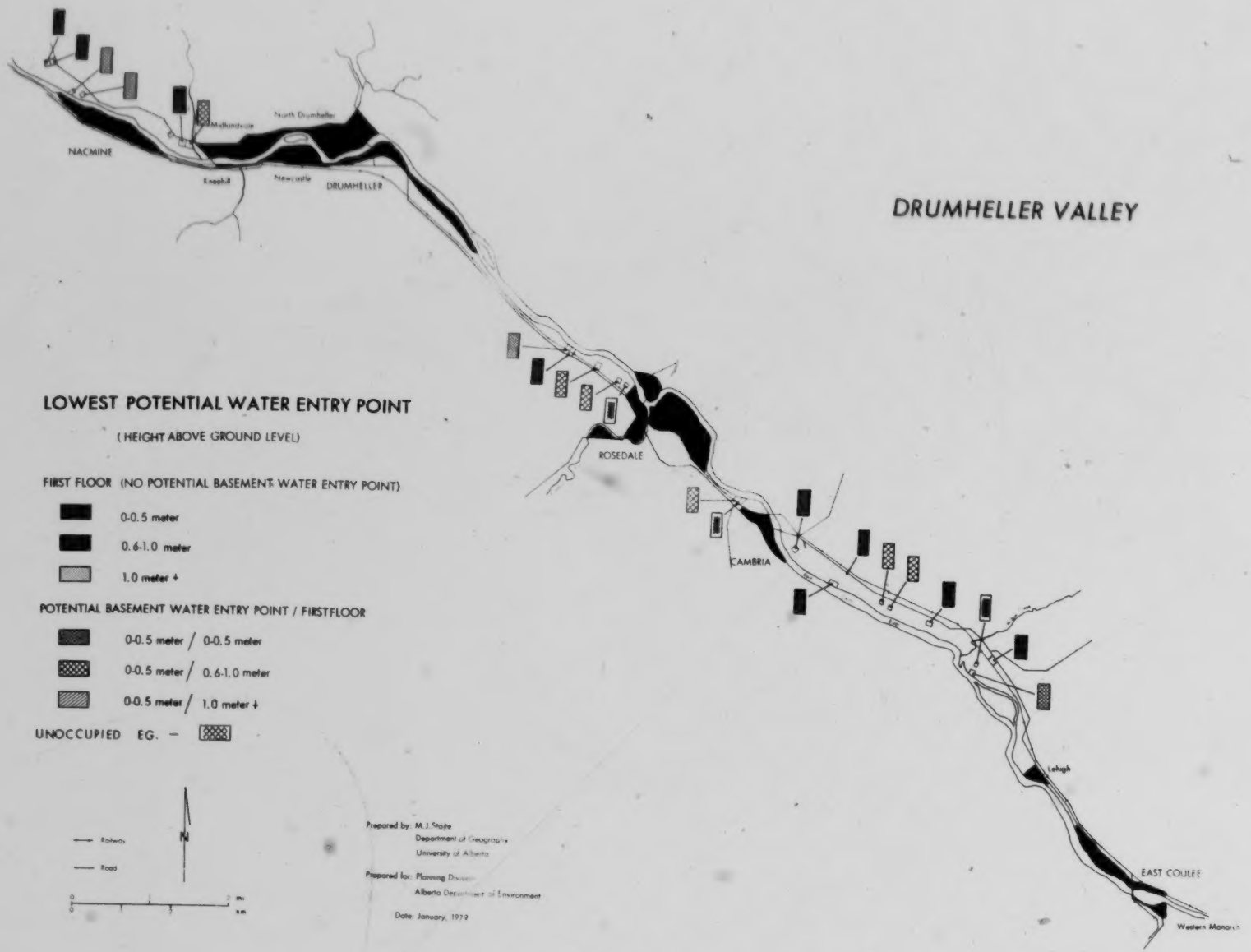
0 1 2 3 km

Prepared by: M. J. Stolte
Department of Geography
University of Alberta

Prepared for: Planning Division
Alberta Department of Environment

Date: January, 1979

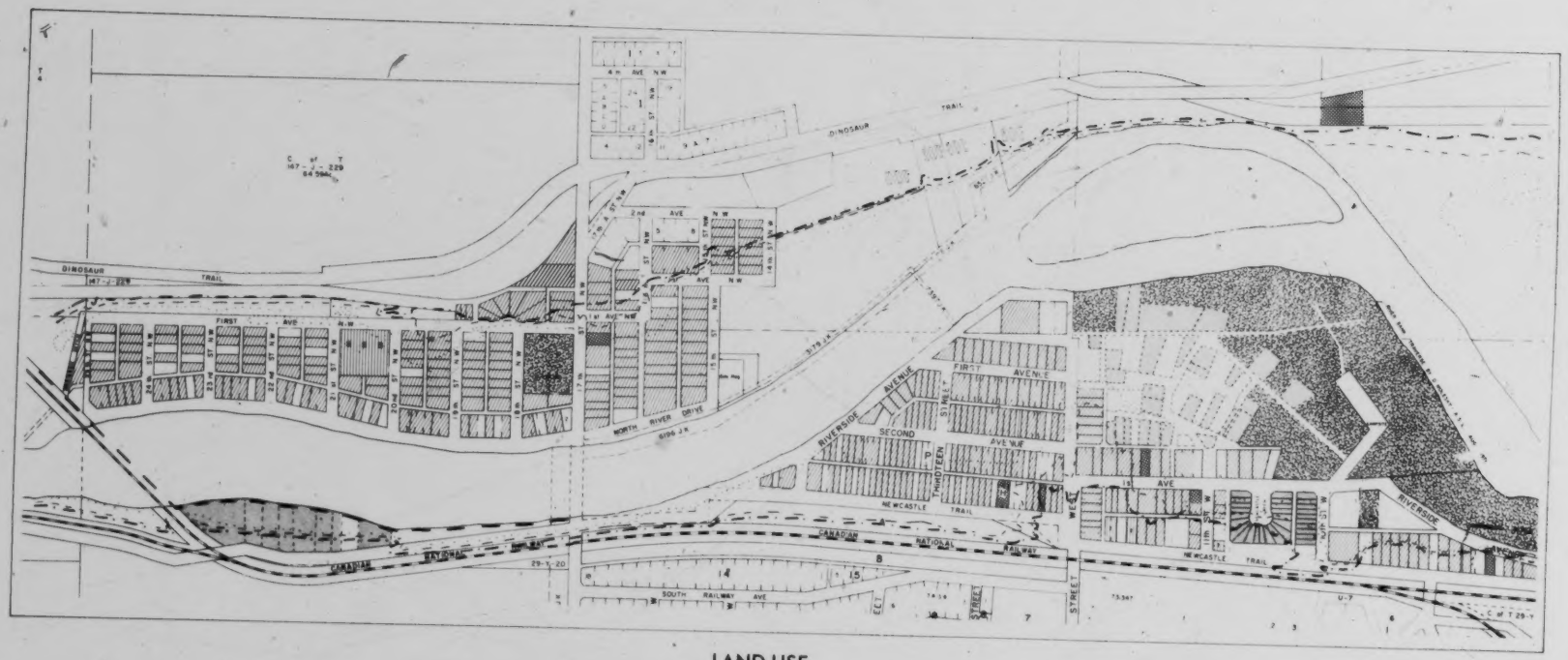

DRUMHELLER VALLEY
NACMINE
Midlandvale
North Drumheller
Newcastle
DRUMHELLER
ROSEDALE
CAMBRIA
Lehigh
EAST COULEE
Western Monarch
BUILDING CLASSIFICATION
OCCUPIED
UNOCCUPIED
B (GOOD)
C (FAIR TO GOOD)
D (FAIR)
E (FAIR TO POOR)
F (POOR)
(AS CLASSIFIED BY ALBERTA DEPARTMENT OF MUNICIPAL AFFAIRS; SEE: Government of the Province of Alberta, 1967 Assessment manual, section iv, pp 1-48)
Railway
Road
N
Prepared by: M. J. Stata
Department of Geography
University of Alberta
Prepared for: Planning Division
Alberta Department of Environment
Date: January, 1979


DRUMHELLER VALLEY
NACMINE
North Drumheller
Midlandvale
Newcastle
DRUMHELLER
ROSEDALE
CAMBRIA
Lehigh
EAST COULEE
LOWEST POTENTIAL WATER ENTRY POINT
(HEIGHT ABOVE GROUND LEVEL)
FIRST FLOOR (NO POTENTIAL BASEMENT WATER ENTRY POINT)
0-0.5 meter
0.6-1.0 meter
1.0 meter +
POTENTIAL BASEMENT WATER ENTRY POINT / FIRSTFLOOR
0-0.5 meter / 0-0.5 meter
0-0.5 meter / 0.6-1.0 meter
0-0.5 meter / 1.0 meter +
UNOCCUPIED EG. –
Railway
Road
N
Prepared by: M. J. Slade
Department of Geography
University of Alberta
Prepared for: Planning Division
Alberta Department of Environment
Date: January, 1979

APPENDIX C

MIDLANDVALE AND NEWCASTLE LAND USE MAPS

MIDLANDVALE-NEWCASTLE



LAND USE

(DOES NOT INCLUDE GARAGES, SUMMER KITCHENS OR OTHER OUTBUILDINGS.)

- SINGLE FAMILY RESIDENTIAL
- TWO FAMILY RESIDENTIAL
- MULTI-FAMILY RESIDENTIAL
- T TRAILER PARK
- C&C CAMPING AND CABINS
- H/M HOTEL/MOTEL
- COMMERCIAL
- INDUSTRIAL/STORAGE
- P/OS PARK/OPEN SPACE
- Ag AGRICULTURAL -HAY/GRAZING
- Ac -CULTIVATED
- P PUBLIC
- S SCHOOL
- CH CHURCH
- SQUATTER
- VACANT

1:100 YEAR FLOODLINE
1:50 YEAR FLOODLINE
1:25 YEAR FLOODLINE

N

meters 0 100 200
feet 0 200 400 600

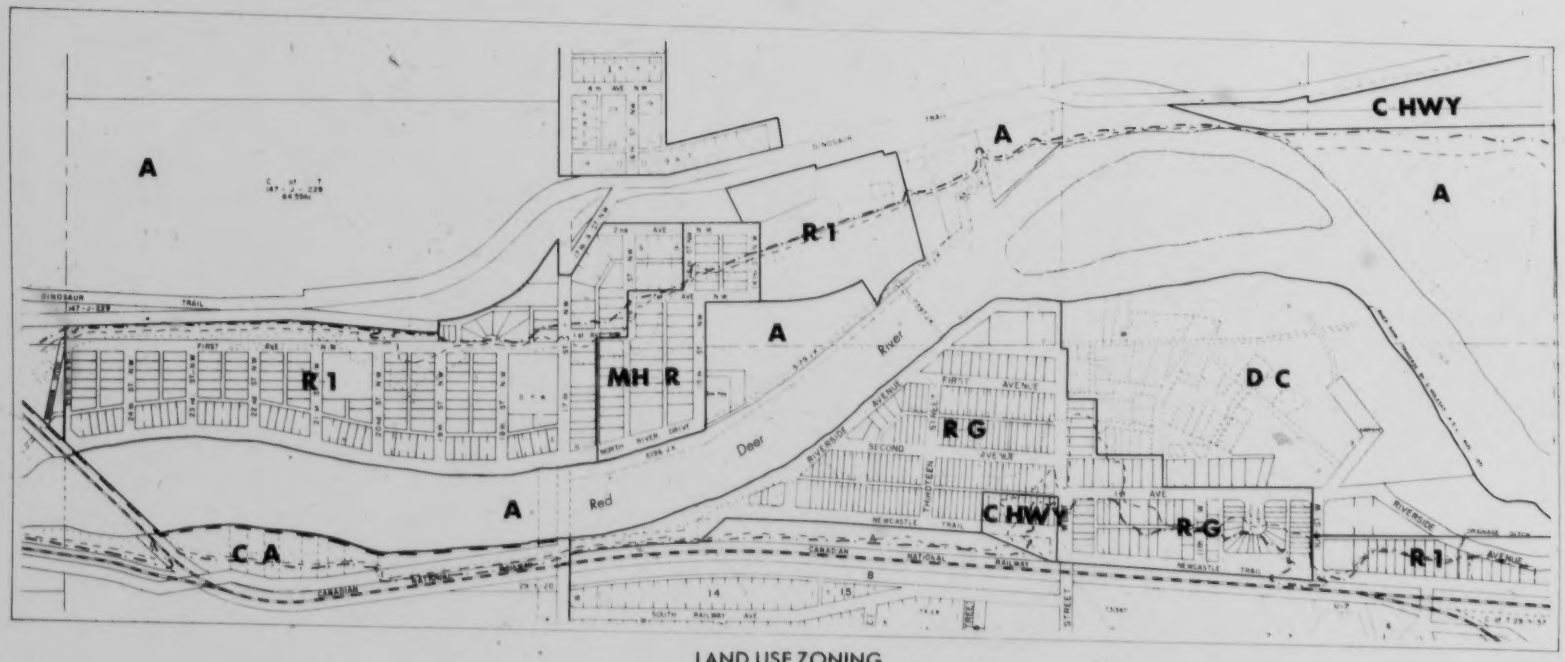
Base map drawn at: Provincial Planning Branch
Alberta Department of Municipal Affairs

Prepared by: M. J. Staite
Department of Geography
University of Alberta

Prepared for: Planning Division
Alberta Department of Environment

Date: January, 1979

MIDLANDVALE-NEWCASTLE



Base map drawn at: Provincial Planning Branch
Alberta Department of Municipal Affairs

LAND USE ZONING

R-1	SINGLE FAMILY RESIDENTIAL DISTRICT
R-2	TWO FAMILY RESIDENTIAL DISTRICT
R-G	GENERAL RESIDENTIAL DISTRICT
MH-P	MOBILE HOME PARK
MH-R	MOBILE HOME RESIDENTIAL DISTRICT
C-B	CENTRAL BUSINESS DISTRICT
C-HWY	HIGHWAY COMMERCIAL DISTRICT
M-2	GENERAL INDUSTRIAL DISTRICT
M-1	RESTRICTED LIGHT INDUSTRIAL DISTRICT
D-C	DIRECT CONTROL DISTRICT
A	AGRICULTURAL DISTRICT
H-R	HAMLET RESIDENTIAL DISTRICT
H-C	HAMLET COMMERCIAL DISTRICT
C-A	CONSERVATION AREA - AGRICULTURAL DISTRICT

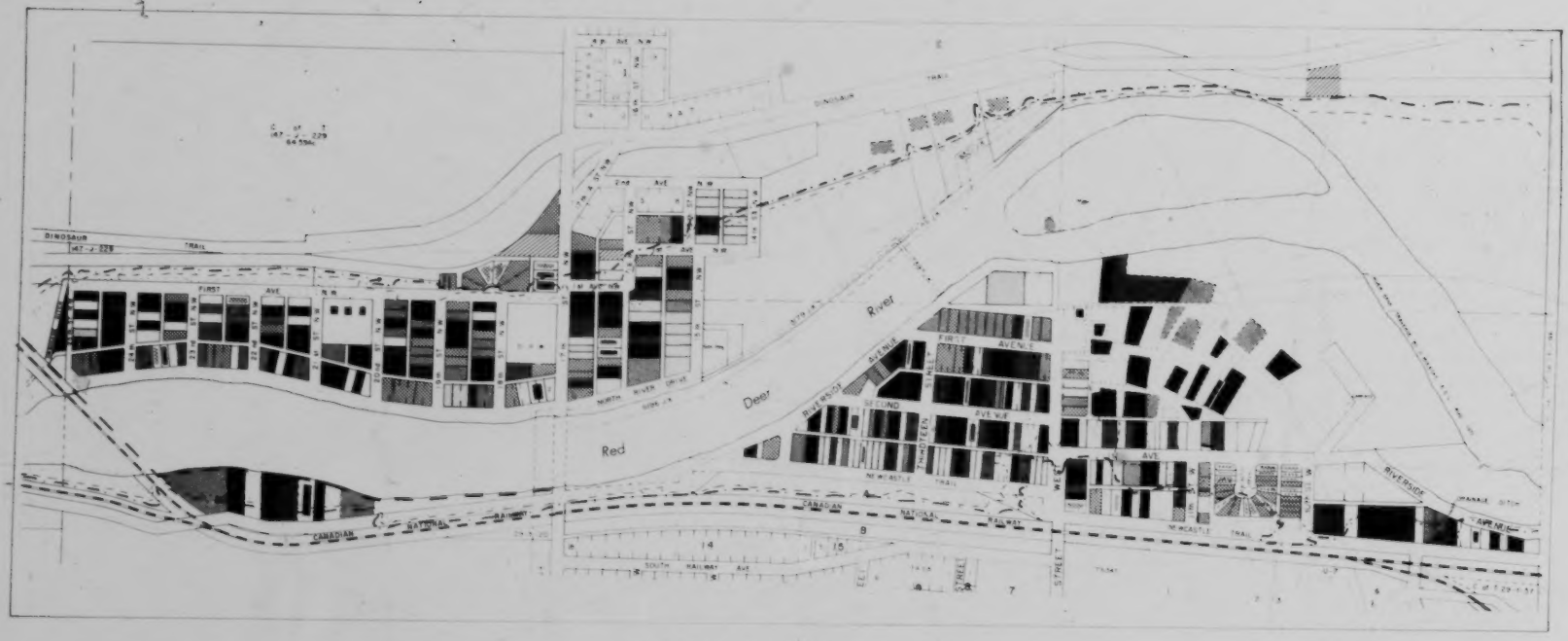
(SOURCE: Improvement District No. 7, 1978, Development Control Bylaw Directions in Force and the City of Drumheller, 1976, Development Control Bylaw, as ammended to Sept., 1978)

Prepared by: M. J. Staite
Department of Geography
University of Alberta

Prepared for: Planning Division
Alberta Department of Environment

Date: January, 1979

MIDLANDVALE-NEWCASTLE



BUILDING CLASSIFICATION

OCCUPIED UNOCCUPIED

- B (GOOD)
- C (FAIR TO GOOD)
- D (FAIR)
- E (FAIR TO POOR)
- F (POOR)
- MOBILE
- QUONSET

(AS CLASSIFIED BY ALBERTA DEPARTMENT OF MUNICIPAL AFFAIRS ; SEE: Government of the Province of Alberta, 1967, Assessment manual, Section iv, 1.48.)

1:100 YEAR FLOODLINE
1:50 YEAR FLOODLINE
1:25 YEAR FLOODLINE

meters 0 100 200
feet 0 200 400 600

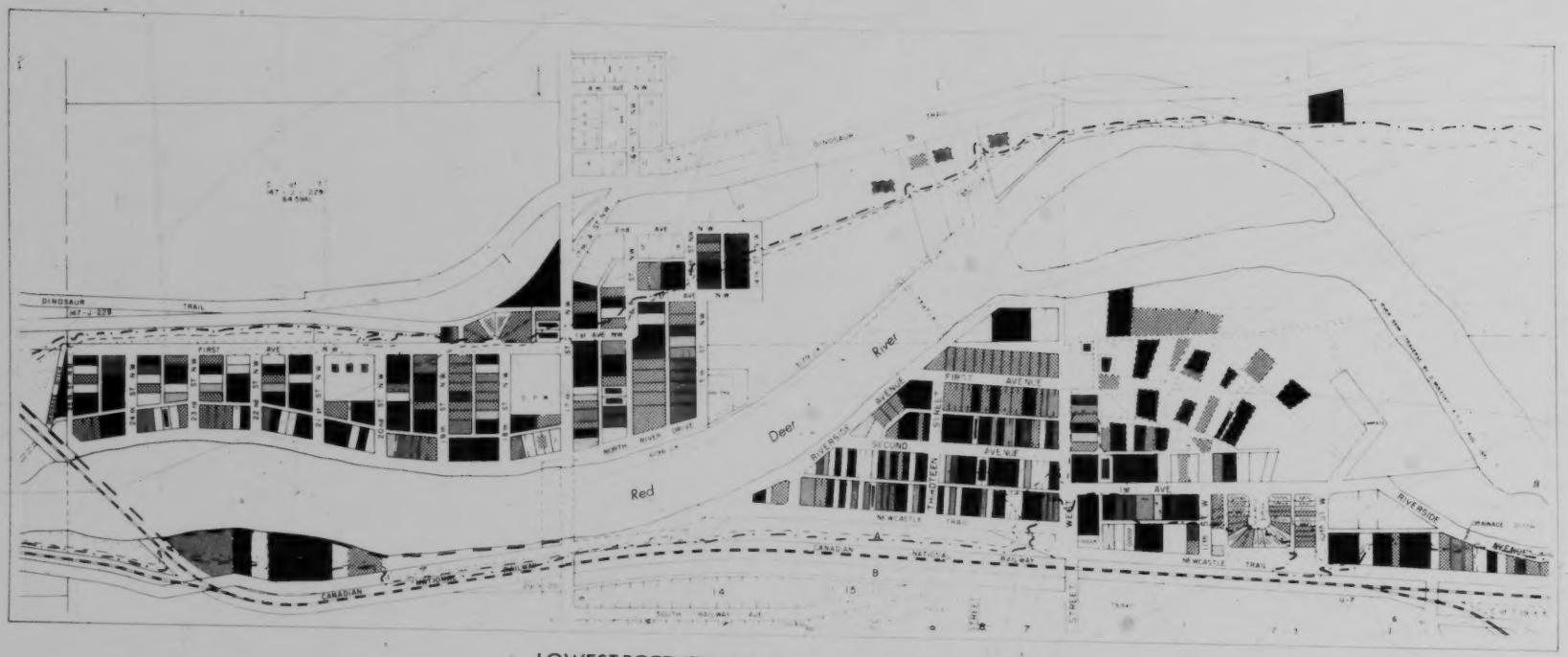
Base map drawn at Provincial Planning Branch
Alberta Department of Municipal Affairs

Prepared by: M. J. Slate
Department of Geography
University of Alberta

Prepared for: Planning Division
Alberta Department of Environment

Date: January, 1979

MIDLANDVALE-NEWCASTLE



1:100 YEAR FLOODLINE
1:50 YEAR FLOODLINE
1:25 YEAR FLOODLINE

N

meters 0 100 200
feet 0 200 400 600

Base map drawn at: Provincial Planning Branch
Alberta Department of Municipal Affairs

LOWEST POTENTIAL WATER ENTRY POINT

(HEIGHT ABOVE GROUND LEVEL)

FIRST FLOOR (NO POTENTIAL BASEMENT WATER ENTRY POINT)

- 0-0.5 meters
- 0.6-1.0 meters
- 1.0 meter

POTENTIAL BASEMENT WATER ENTRY POINT / FIRST FLOOR

- 0-0.5 meters / 0-0.5 meters
- 0-0.5 meters / 0.6-1.0 meters
- 0-0.5 meters / 1.0 meter

UNOCCUPIED EG.

Prepared by: M. J. Slaite
Department of Geography
University of Alberta

Prepared for: Planning Division
Alberta Department of Environment

Date: January, 1979

APPENDIX D

NORTH DRUMHELLER AND DRUMHELLER LAND USE MAPS

DRUMHELLER

LAND USE

(DOES NOT INCLUDE GARAGES, SUMMER KITCHENS OR OTHER OUTBUILDINGS.)

- SINGLE FAMILY RESIDENTIAL
- TWO FAMILY RESIDENTIAL
- MULTI-FAMILY RESIDENTIAL
- TRAILER PARK
- CAMPING AND CABINS
- HOTEL/MOTEL
- COMMERCIAL
- INDUSTRIAL/STORAGE
- PARK/OPEN SPACE
- AGRICULTURAL -HAY/GRAZING
- -CULTIVATED
- PUBLIC
- SCHOOL
- CHURCH
- SQUATTER
- VACANT

1:100 YEAR FLOODLINE
1:50 YEAR FLOODLINE
1:25 YEAR FLOODLINE

metres 0 100 200 300
feet 0 200 400 600 800 1000

Base map drawn at: Provincial Planning Branch
Alberta Department of Municipal Affairs

Prepared by: M. J. Slaite
Department of Geography
University of Alberta

Prepared for: Planning Division
Alberta Department of Environment

Date: January, 1979

DRUMHELLER

LAND USE ZONING

R-1	SINGLE FAMILY RESIDENTIAL DISTRICT
R-2	TWO FAMILY RESIDENTIAL DISTRICT
R-G	GENERAL RESIDENTIAL DISTRICT
MH-P	MOBILE HOME PARK
MH-R	MOBILE HOME RESIDENTIAL DISTRICT
C-B	CENTRAL BUSINESS DISTRICT
C-HWY	HIGHWAY COMMERCIAL DISTRICT
M-2	GENERAL INDUSTRIAL DISTRICT
M-1	RESTRICTED LIGHT INDUSTRIAL DISTRICT
D-C	DIRECT CONTROL DISTRICT
A	AGRICULTURAL DISTRICT
H-R	HAMLET RESIDENTIAL DISTRICT
H-C	HAMLET COMMERCIAL DISTRICT
C-A	CONSERVATION AREA - AGRICULTURAL DISTRICT

1:100 YEAR FLOODLINE —··—

1:50 YEAR FLOODLINE – – –

1:25 YEAR FLOODLINE

metres 0 100 200 300

feet 0 200 400 600 800 1000

Base map drawn at Provincial Planning Branch
Alberta Department of Municipal Affairs

(SOURCE: Improvement District No. 7, 1978, Development Control Bylaw Directions in Force and the City of Drumheller, 1976, Development Control Bylaw, as ammended to Sept., 1978)

Prepared by: M. J. Stolte
Department of Geography
University of Alberta

Prepared for: Planning Division
Alberta Department of Environment

Date: January, 1979

DRUMHELLER

BUILDING CLASSIFICATION

OCCUPIED	UNOCCUPIED	
		B (GOOD)
		C (FAIR TO GOOD)
		D (FAIR)
		E (FAIR TO POOR)
		F (POOR)
		MOBILE
		QUONSET

(AS CLASSIFIED BY ALBERTA DEPARTMENT OF MUNICIPAL AFFAIRS ; SEE: Government of the Province of Alberta, 1967, Assessment manual, Section iv, 1-48.)

1:100 YEAR FLOODLINE
1:50 YEAR FLOODLINE
1:25 YEAR FLOODLINE

N

meters 0 100 200 300
feet 0 200 400 600 800 1000

Base map drawn at: Provincial Planning Branch
Alberta Department of Municipal Affairs

Prepared by: M. J. Slaite
Department of Geography
University of Alberta

Prepared for: Planning Division
Alberta Department of Environment

Date: January, 1979

DRUMHELLER

LOWEST POTENTIAL WATER ENTRY POINT

(HEIGHT ABOVE GROUND LEVEL)

1:100 YEAR FLOODLINE

1:50 YEAR FLOODLINE

1:25 YEAR FLOODLINE

FIRST FLOOR (NO POTENTIAL BASEMENT WATER ENTRY POINT)

- 0-0.5 meter
- 0.6-1.0 meter
- 1.0 meter

POTENTIAL BASEMENT WATER ENTRY POINT / FIRST FLOOR

- 0-0.5 meter / 0-0.5 meter
- 0-0.5 meter / 0.6-1.0 meter
- 0-0.5 meter / 1.0 meter

UNOCCUPIED EG:

meters 0 100 200 300
feet 0 200 400 600 800 1000

Base map drawn at: Provincial Planning Branch
Alberta Department of Municipal Affairs

Prepared by: M.J. Slate
Department of Geography
University of Alberta

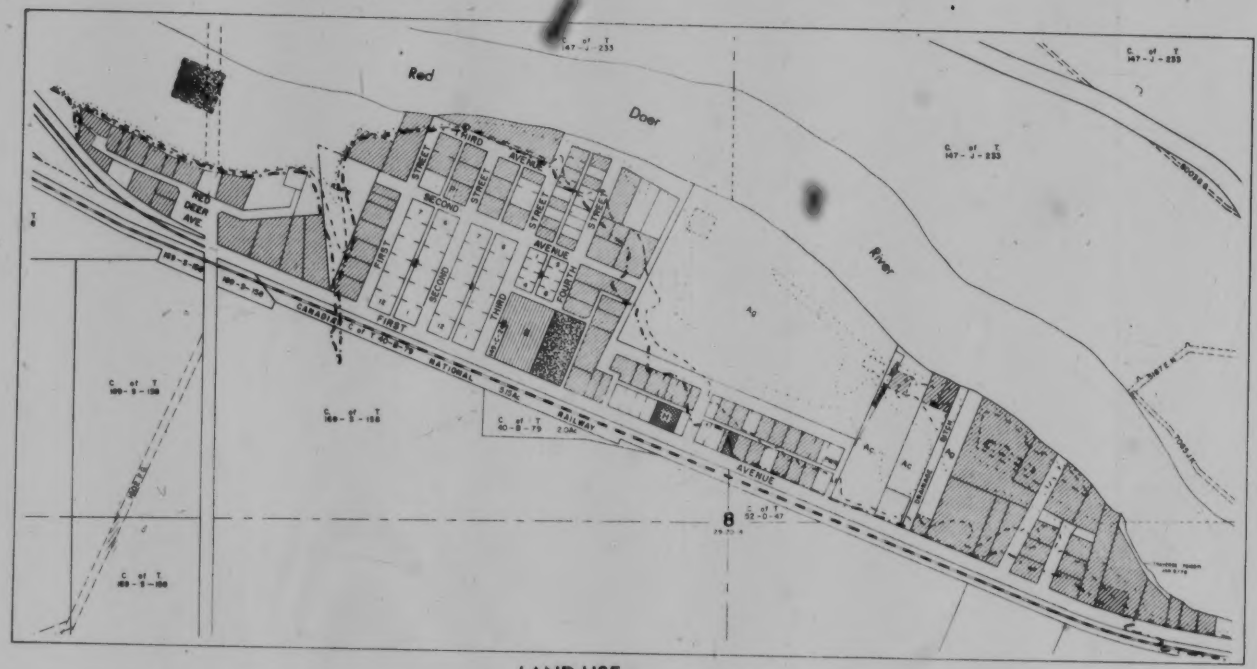
Prepared for: Planning Division
Alberta Department of Environment

Date: January, 1979

APPENDIX E

NACMINE LAND USE MAPS

NACMINE



LAND USE

(DOES NOT INCLUDE GARAGES, SUMMER KITCHENS OR OTHER OUTBUILDINGS.)

- SINGLE FAMILY RESIDENTIAL
- TWO FAMILY RESIDENTIAL
- MULTI-FAMILY RESIDENTIAL
- TRAILER PARK
- CAMPING AND CABINS
- HOTEL/MOTEL
- COMMERCIAL
- INDUSTRIAL/STORAGE
- PARK /OPEN SPACE
- AGRICULTURAL -HAY/GRAZING
- -CULTIVATED
- PUBLIC
- SCHOOL
- CHURCH
- SQUATTER
- VACANT
- 1:100 YEAR FLOODLINE
- 1:50 YEAR FLOODLINE
- 1:25 YEAR FLOODLINE

N

meters 0 100 200
feet 0 200 400 600

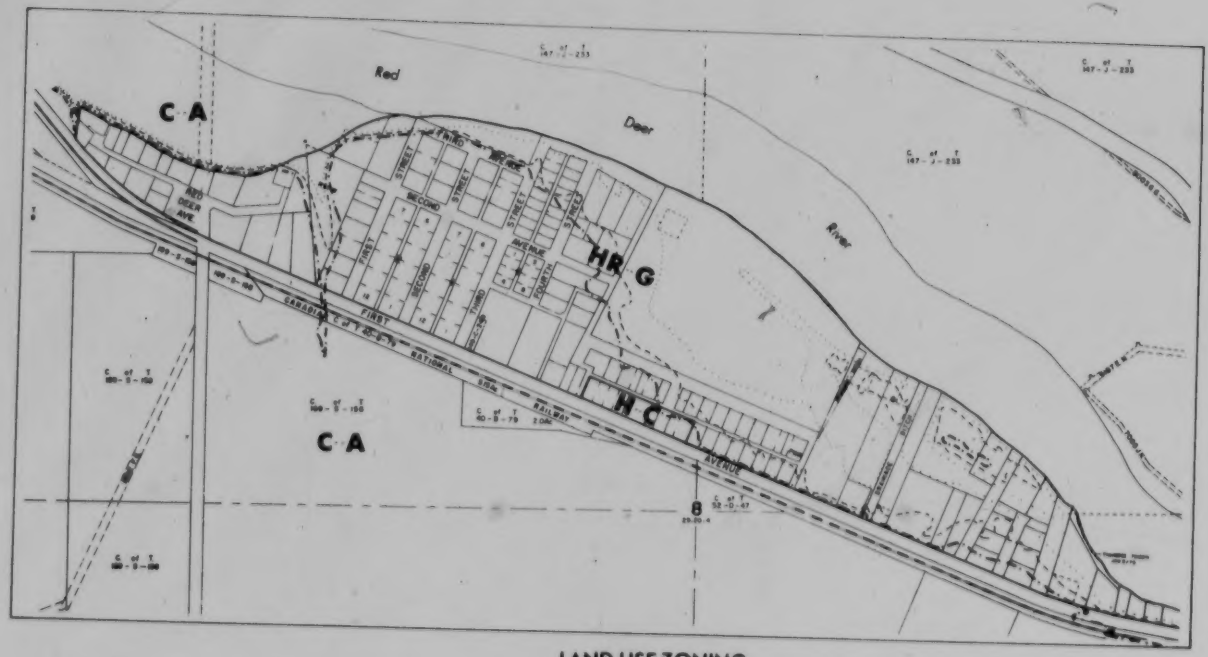
Base map drawnat: Provincial Planning Branch
Alberta Department of Municipal Affairs

Prepared by: M. J. Stoike
Department of Geography
University of Alberta

Prepared for: Planning Division
Alberta Department of Environment

Date: January, 1979

NACMINE



LAND USE ZONING

R-1	SINGLE FAMILY RESIDENTIAL DISTRICT
R-2	TWO FAMILY RESIDENTIAL DISTRICT
R-G	GENERAL RESIDENTIAL DISTRICT
MH-P	MOBILE HOME PARK
MH-R	MOBILE HOME RESIDENTIAL DISTRICT
C-B	CENTRAL BUSINESS DISTRICT
C-HWY	HIGHWAY COMMERCIAL DISTRICT
M-2	GENERAL INDUSTRIAL DISTRICT
M-1	RESTRICTED LIGHT INDUSTRIAL DISTRICT
D-C	DIRECT CONTROL DISTRICT
A	AGRICULTURAL DISTRICT
H-R	HAMLET RESIDENTIAL DISTRICT
H-C	HAMLET COMMERCIAL DISTRICT
C-A	CONSERVATION AREA - AGRICULTURAL DISTRICT

1:100 YEAR FLOODLINE
1:50 YEAR FLOODLINE
1:25 YEAR FLOODLINE

metres 0 100 200
feet 0 200 400 600

Base map drawn at: Provincial Planning Branch
Alberta Department of Municipal Affairs

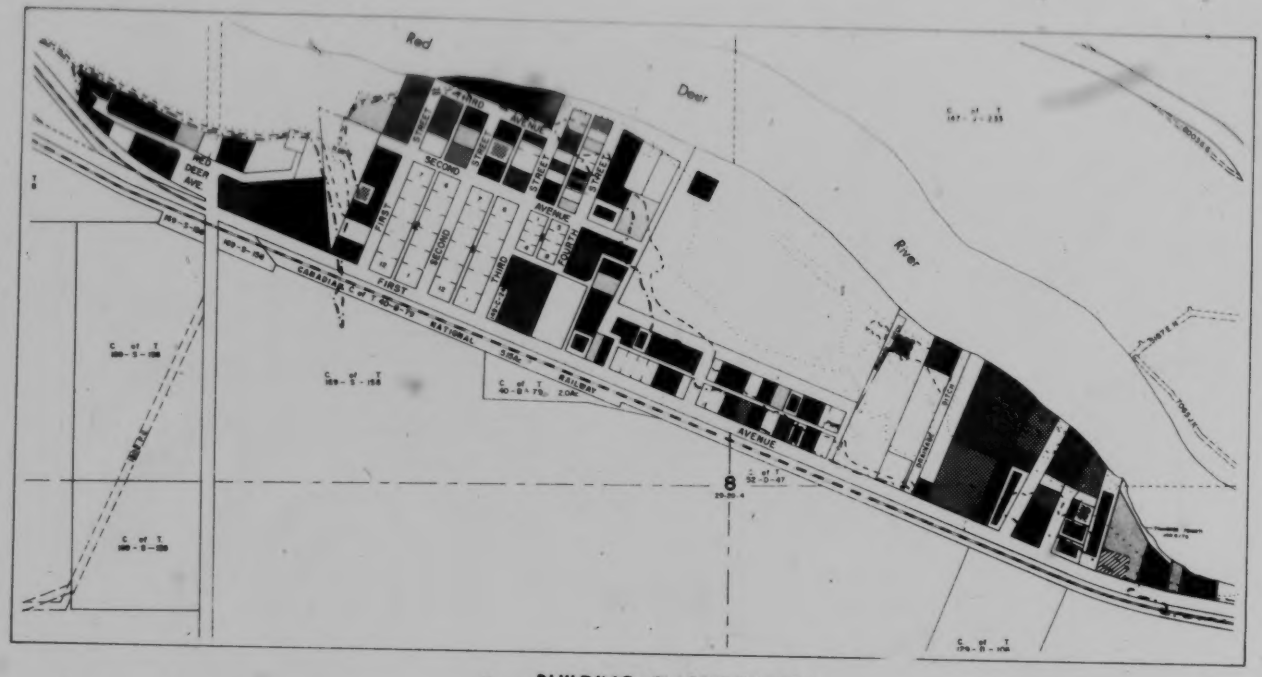
(SOURCE: Improvement District No. 7, 1978, Development Control Bylaw Directions in Force and the City of Drumheller, 1976, Development Control Bylaw, as ammended to Sept., 1978)

Prepared by: M. J. Stolte
Department of Geography
University of Alberta

Prepared for: Planning Division
Alberta Department of Environment

Date: January, 1979

NACMINE



BUILDING CLASSIFICATION

OCCUPIED	UNOCCUPIED	
		B (GOOD)
		C (FAIR TO GOOD)
		D (FAIR)
		E (FAIR TO POOR)
		F (POOR)
		MOBILE
		QUONSET

(AS CLASSIFIED BY ALBERTA DEPARTMENT OF MUNICIPAL AFFAIRS ; SEE: Government of the Province of Alberta, 1967, Assessment manual, Section iv, 1-48.)

1:100 YEAR FLOODLINE
1:50 YEAR FLOODLINE
1:25 YEAR FLOODLINE

meters 0 100 200
feet 0 200 400 600

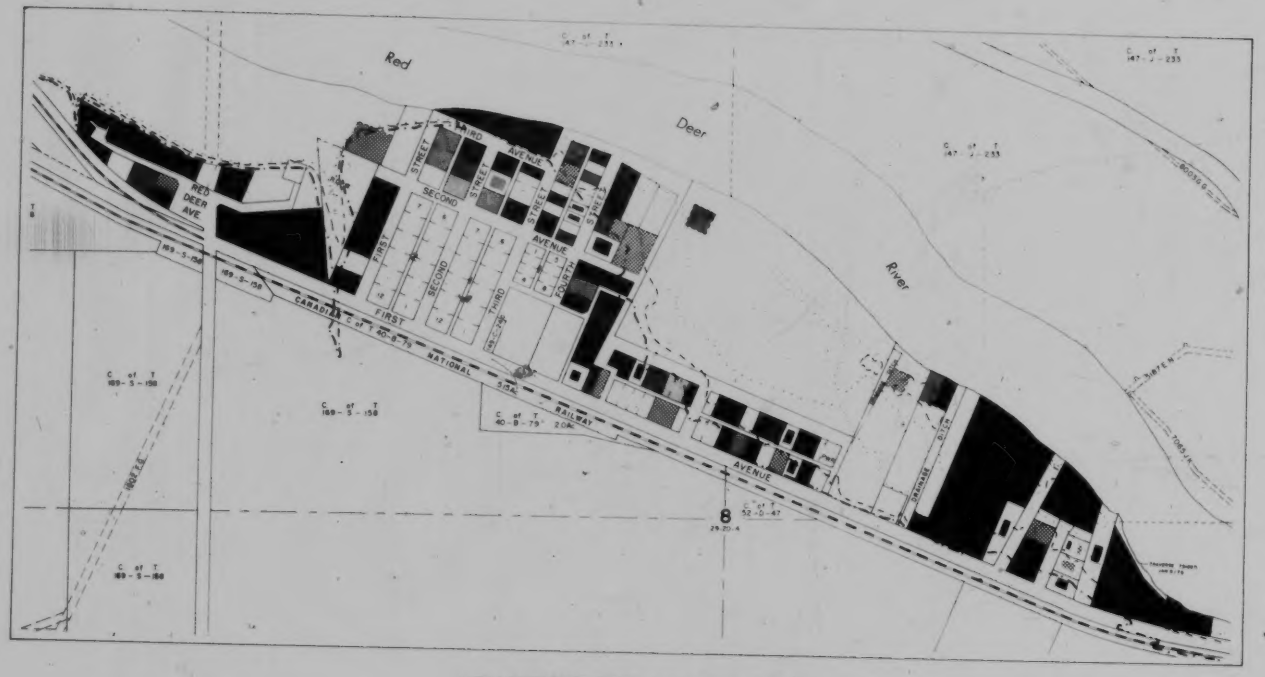
Base map drawn at: Provincial Planning Branch
Alberta Department of Municipal Affairs

Prepared by: M. J. Stelfox
Department of Geography
University of Alberta

Prepared for: Planning Division
Alberta Department of Environment

Date: January, 1979

NACMINE



LOWEST POTENTIAL WATER ENTRY POINT

(HEIGHT ABOVE GROUND LEVEL)

FIRST FLOOR (NO POTENTIAL BASEMENT WATER ENTRY POINT)

- 0-0.5 meters
- 0.6-1.0 meters
- 1.0 meter

POTENTIAL BASEMENT WATER ENTRY POINT / FIRST FLOOR

- 0-0.5 meters / 0-0.5 meters
- 0-0.5 meters / 0.6-1.0 meters
- 0-0.5 meters / 1.0 meter

UNOCCUPIED EG.

1:100 YEAR FLOODLINE

1:50 YEAR FLOODLINE

1:25 YEAR FLOODLINE

N

meters 0 100 200

feet 0 200 400 600

Base map drawn at: Provincial Planning Branch
Alberta Department of Municipal Affairs

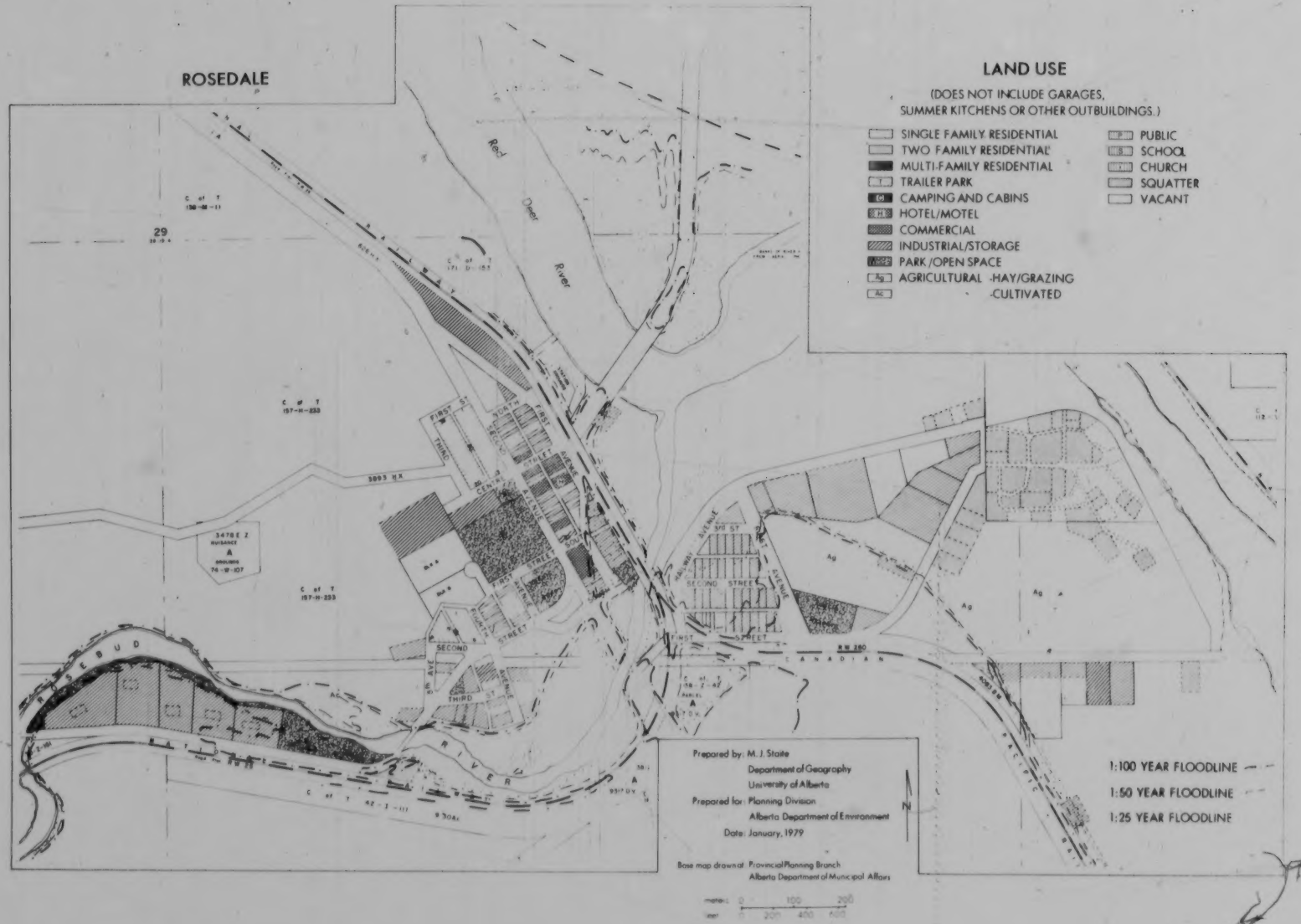
Prepared by: M. J. Staite
Department of Geography
University of Alberta

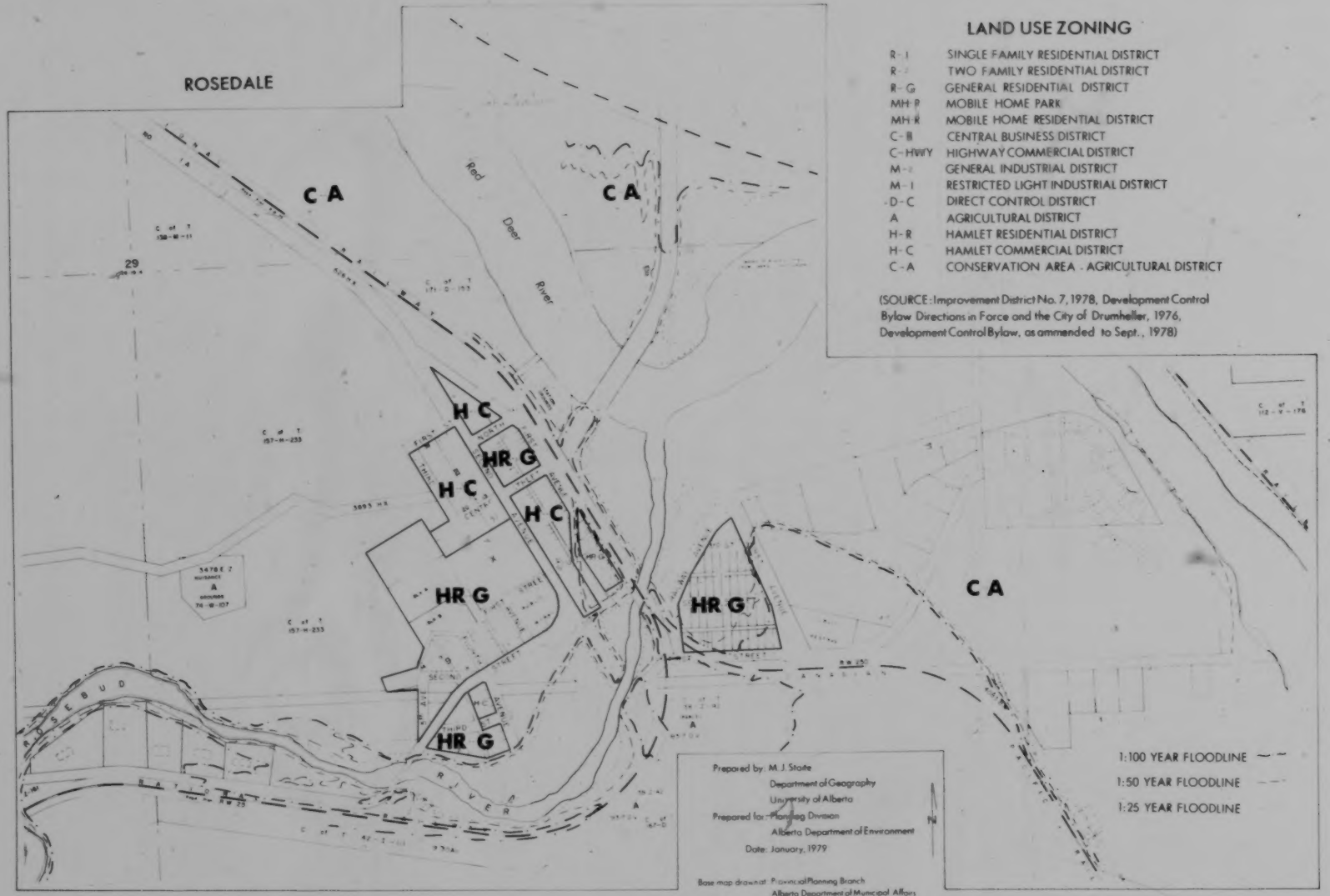
Prepared for: Planning Division
Alberta Department of Environment

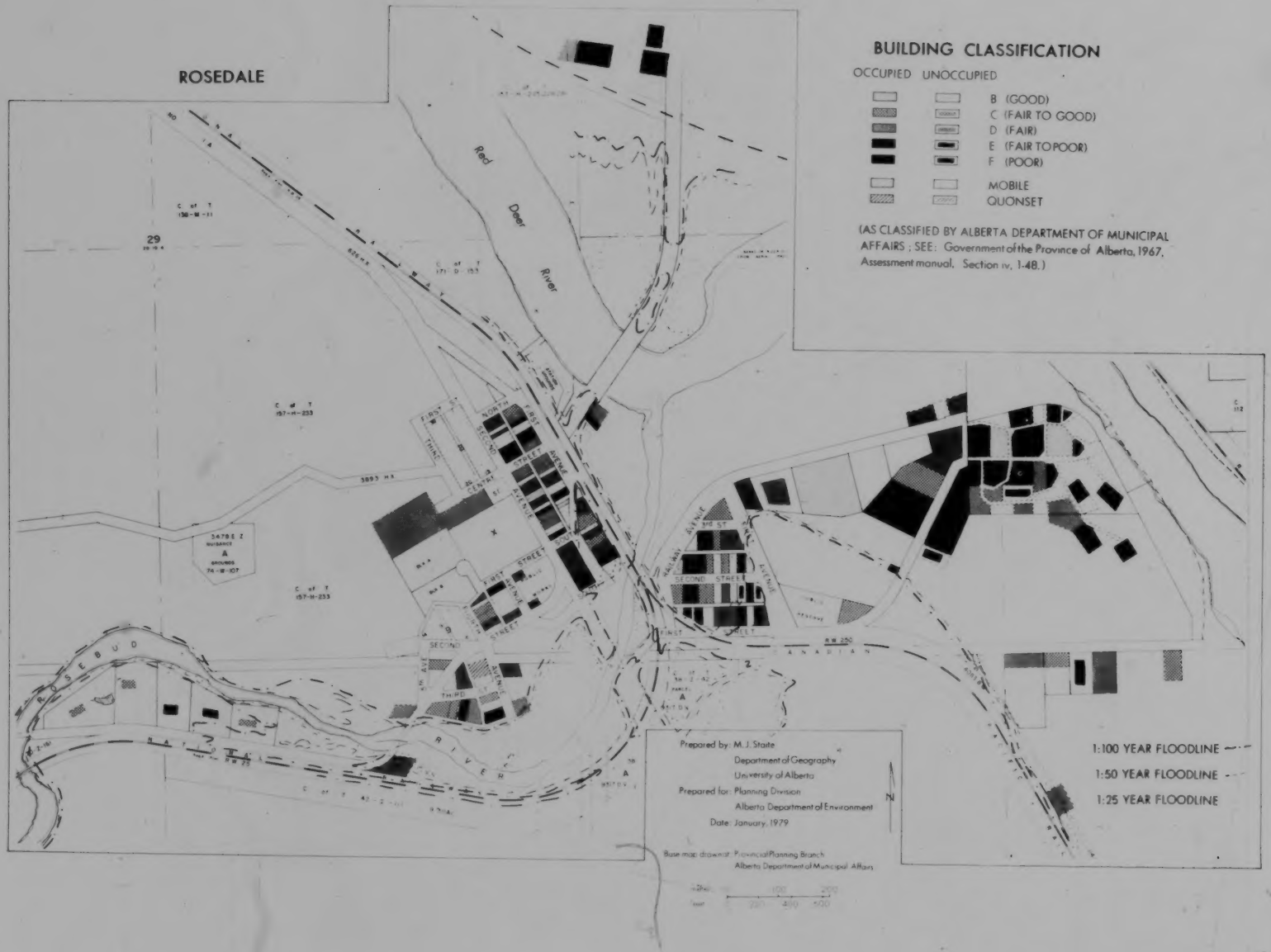
Date: January, 1979

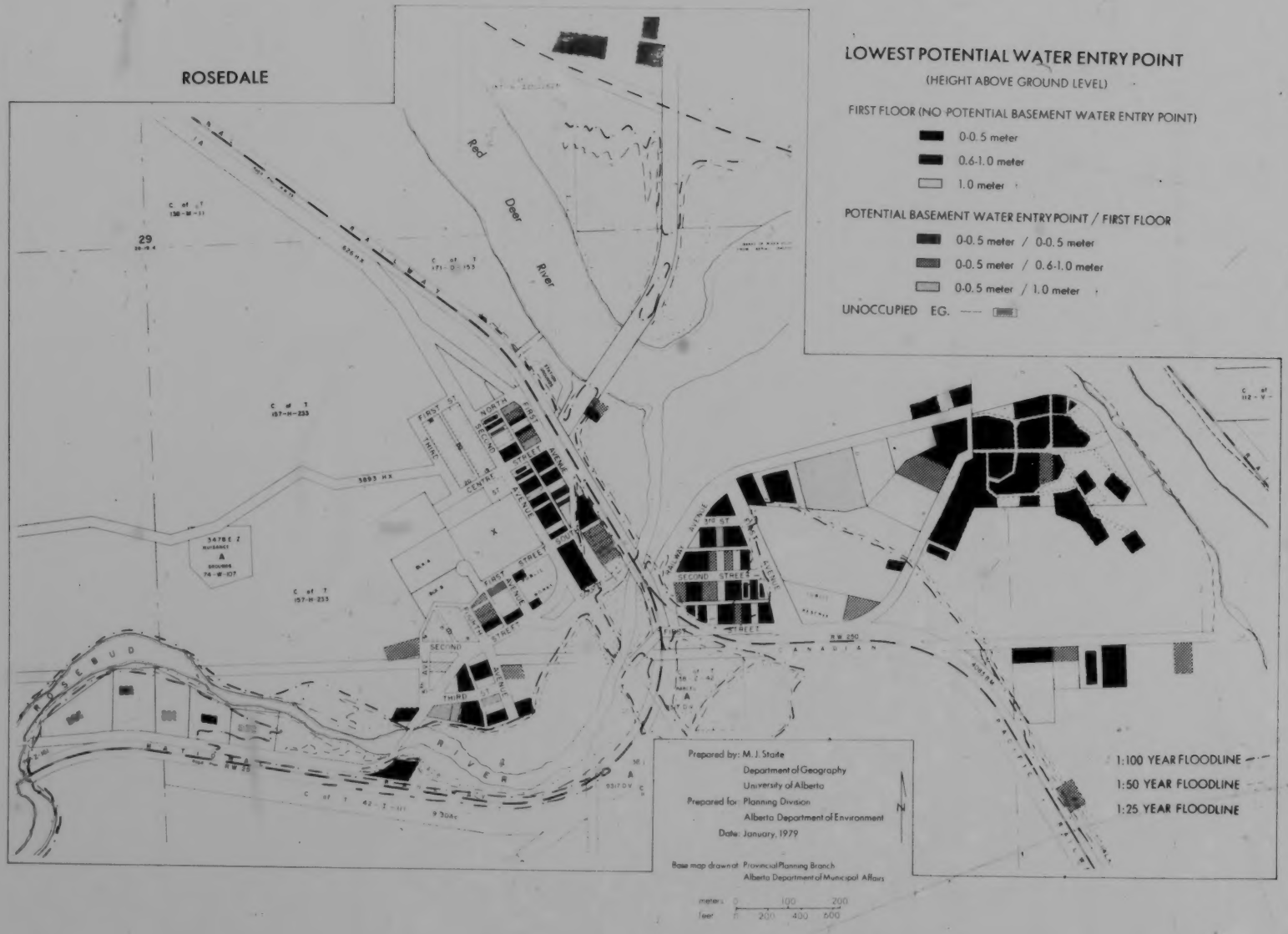
APPENDIX F

ROSEDALE LAND USE MAPS


ROSEDALE
LAND USE
(DOES NOT INCLUDE GARAGES, SUMMER KITCHENS OR OTHER OUTBUILDINGS.)
SINGLE FAMILY RESIDENTIAL
TWO FAMILY RESIDENTIAL
MULTI-FAMILY RESIDENTIAL
TRAILER PARK
CAMPING AND CABINS
HOTEL/MOTEL
COMMERCIAL
INDUSTRIAL/STORAGE
PARK /OPEN SPACE
AGRICULTURAL -HAY/GRAZING
-CULTIVATED
PUBLIC
SCHOOL
CHURCH
SQUATTER
VACANT
Red Deer River
ROSEBUD RIVER
CANADIAN PACIFIC
FIRST STREET
SECOND STREET
THIRD STREET
1:100 YEAR FLOODLINE
1:50 YEAR FLOODLINE
1:25 YEAR FLOODLINE
Prepared by: M. J. Staite
Department of Geography
University of Alberta
Prepared for: Planning Division
Alberta Department of Environment
Date: January, 1979
Base map drawn at Provincial Planning Branch
Alberta Department of Municipal Affairs


ROSEDALE
C A
C A
Red Deer River
H C
HR G
H C
H C
HR G
HR G
C A
ROSEBUD RIVER
LAND USE ZONING
R-1 SINGLE FAMILY RESIDENTIAL DISTRICT
R-2 TWO FAMILY RESIDENTIAL DISTRICT
R-G GENERAL RESIDENTIAL DISTRICT
MH-P MOBILE HOME PARK
MH-R MOBILE HOME RESIDENTIAL DISTRICT
C-B CENTRAL BUSINESS DISTRICT
C-HWY HIGHWAY COMMERCIAL DISTRICT
M-2 GENERAL INDUSTRIAL DISTRICT
M-1 RESTRICTED LIGHT INDUSTRIAL DISTRICT
D-C DIRECT CONTROL DISTRICT
A AGRICULTURAL DISTRICT
H-R HAMLET RESIDENTIAL DISTRICT
H-C HAMLET COMMERCIAL DISTRICT
C-A CONSERVATION AREA - AGRICULTURAL DISTRICT
(SOURCE: Improvement District No. 7, 1978, Development Control Bylaw Directions in Force and the City of Drumheller, 1976, Development Control Bylaw, as ammended to Sept., 1978)
1:100 YEAR FLOODLINE
1:50 YEAR FLOODLINE
1:25 YEAR FLOODLINE
Prepared by: M. J. Slate
Department of Geography
University of Alberta
Prepared for: Planning Division
Alberta Department of Environment
Date: January, 1979
Base map drawn at: Provincial Planning Branch
Alberta Department of Municipal Affairs

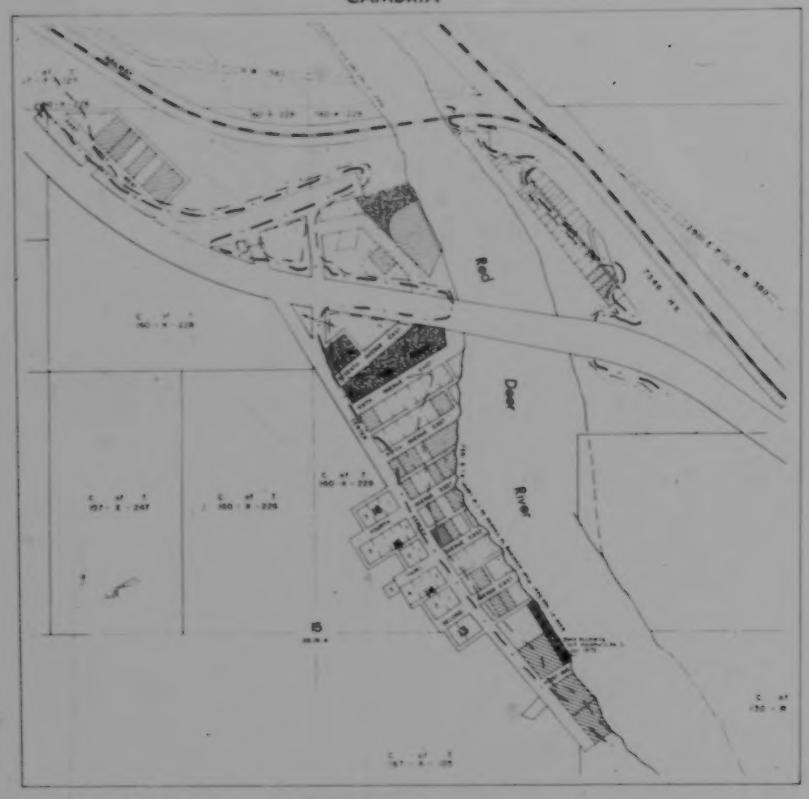

ROSEDALE
Red Deer River
BUILDING CLASSIFICATION
OCCUPIED UNOCCUPIED
B (GOOD)
C (FAIR TO GOOD)
D (FAIR)
E (FAIR TO POOR)
F (POOR)
MOBILE
QUONSET
(AS CLASSIFIED BY ALBERTA DEPARTMENT OF MUNICIPAL AFFAIRS ; SEE: Government of the Province of Alberta, 1967, Assessment manual, Section iv, 1-48.)
1:100 YEAR FLOODLINE
1:50 YEAR FLOODLINE
1:25 YEAR FLOODLINE
Prepared by: M.J. Staite
Department of Geography
University of Alberta
Prepared for: Planning Division
Alberta Department of Environment
Date: January, 1979
Base map drawn at: Provincial Planning Branch
Alberta Department of Municipal Affairs


ROSEDALE
LOWEST POTENTIAL WATER ENTRY POINT
(HEIGHT ABOVE GROUND LEVEL)
FIRST FLOOR (NO POTENTIAL BASEMENT WATER ENTRY POINT)
0-0.5 meter
0.6-1.0 meter
1.0 meter
POTENTIAL BASEMENT WATER ENTRY POINT / FIRST FLOOR
0-0.5 meter / 0-0.5 meter
0-0.5 meter / 0.6-1.0 meter
0-0.5 meter / 1.0 meter
UNOCCUPIED EG.
Red Deer River
1:100 YEAR FLOODLINE
1:50 YEAR FLOODLINE
1:25 YEAR FLOODLINE
Prepared by: M. J. Stafe
Department of Geography
University of Alberta
Prepared for: Planning Division
Alberta Department of Environment
Date: January, 1979
Base map drawn at Provincial Planning Branch
Alberta Department of Municipal Affairs
meters 0 100 200
feet 0 200 400 600

APPENDIX G

CAMBRIA LAND USE MAPS

CAMBRIA



LAND USE

(DOES NOT INCLUDE GARAGES, SUMMER KITCHENS OR OTHER OUTBUILDINGS.)

- SINGLE FAMILY RESIDENTIAL
- TWO FAMILY RESIDENTIAL
- MULTI-FAMILY RESIDENTIAL
- TRAILER PARK
- CAMPING AND CABINS
- HOTEL/MOTEL
- COMMERCIAL
- INDUSTRIAL/STORAGE
- PARK /OPEN SPACE
- AGRICULTURAL -HAY/GRAZING
- CULTIVATED
- PUBLIC
- SCHOOL
- CHURCH
- SQUATTER
- VACANT

1:100 YEAR FLOODLINE
1:50 YEAR FLOODLINE
1:25 YEAR FLOODLINE

meters 0 100 200
feet 0 200 400 600

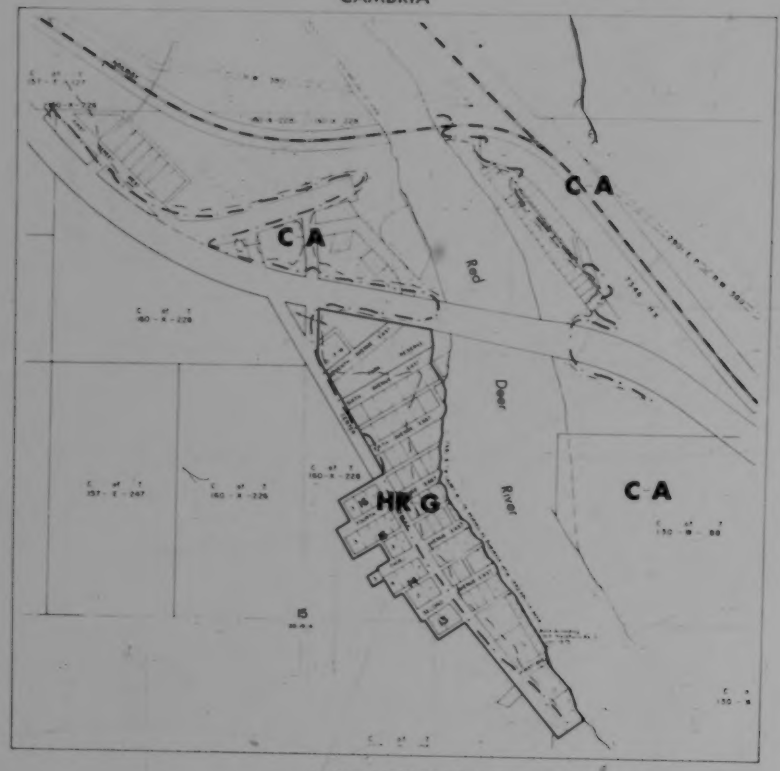
Base map drawn at: Provincial Planning Branch
Alberta Department of Municipal Affairs

Prepared by: M. J. Slaite
Department of Geography
University of Alberta

Prepared for: Planning Division
Alberta Department of Environment

Date: January, 1979

CAMBRIA



LAND USE ZONING

R-1	SINGLE FAMILY RESIDENTIAL DISTRICT
R-2	TWO FAMILY RESIDENTIAL DISTRICT
R-G	GENERAL RESIDENTIAL DISTRICT
MH-P	MOBILE HOME PARK
MH-R	MOBILE HOME RESIDENTIAL DISTRICT
C-B	CENTRAL BUSINESS DISTRICT
C-HWY	HIGHWAY COMMERCIAL DISTRICT
M-2	GENERAL INDUSTRIAL DISTRICT
M-1	RESTRICTED LIGHT INDUSTRIAL DISTRICT
D-C	DIRECT CONTROL DISTRICT
A	AGRICULTURAL DISTRICT
H-R	HAMLET RESIDENTIAL DISTRICT
H-C	HAMLET COMMERCIAL DISTRICT
C-A	CONSERVATION AREA - AGRICULTURAL DISTRICT

1:100 YEAR FLOODLINE
1:50 YEAR FLOODLINE
1:25 YEAR FLOODLINE

N

metres 0 100 200
feet 0 200 400 600

Base map drawn at: Provincial Planning Branch
Alberta Department of Municipal Affairs

(SOURCE: Improvement District No. 7, 1978, Development Control Bylaw Directions in Force and the City of Drumheller, 1976, Development Control Bylaw (recommended to Sept., 1978))

Prepared by: M. J. Stabe
Department of Geography
University of Alberta

Prepared for: Planning Division
Alberta Department of Environment

Date: January, 1979

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CAMBRIA

BUILDING CLASSIFICATION

OCCUPIED	UNOCCUPIED	
		B (GOOD)
		C (FAIR TO GOOD)
		D (FAIR)
		E (FAIR TO POOR)
		F (POOR)
		MOBILE
		QUONSET

(AS CLASSIFIED BY ALBERTA DEPARTMENT OF MUNICIPAL AFFAIRS, SEE: Government of the Province of Alberta, 1967, Assessment manual, Section iv, 1-48.)

1:100 YEAR FLOODLINE

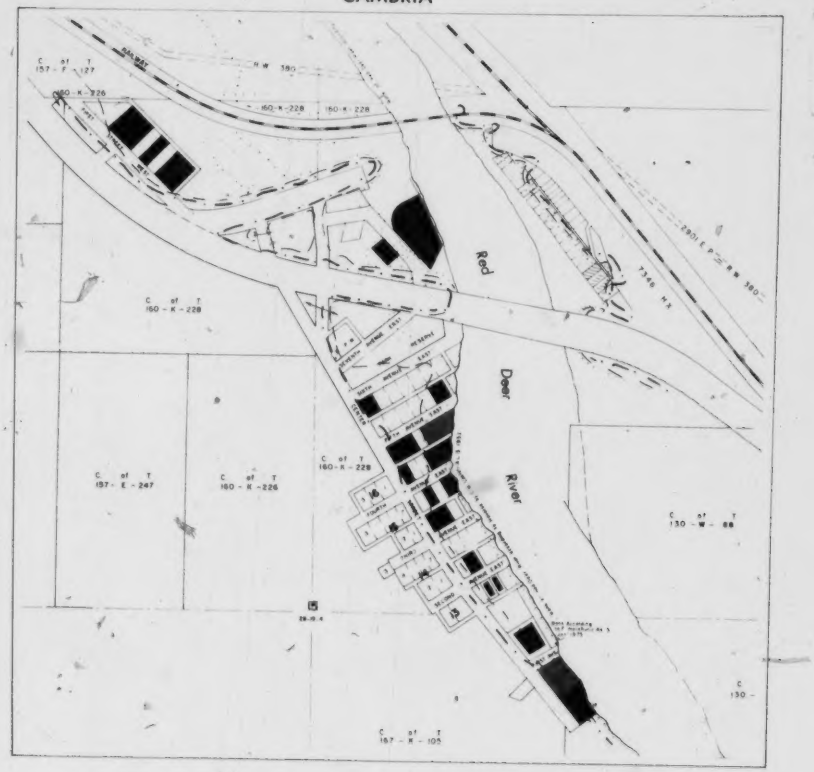
1:50 YEAR FLOODLINE

1:25 YEAR FLOODLINE

Prepared by: M. J. Stelte
Department of Geography
University of Alberta

Prepared for: Planning Division
Alberta Department of Environment

CAMBRIA



LOWEST POTENTIAL WATER ENTRY POINT

(HEIGHT ABOVE GROUND LEVEL)

FIRST FLOOR (NO POTENTIAL BASEMENT WATER ENTRY POINT)

- 0-0.5 meters
- 0.6-1.0 meters
- 1.0 meter +

POTENTIAL BASEMENT WATER ENTRY POINT / FIRST FLOOR

- 0-0.5 meters / 0-0.5 meters
- 0-0.5 meters / 0.6-1.0 meters
- 0-0.5 meters / 1.0 meter +

UNOCCUPIED EG. ——

1:100 YEAR FLOODLINE — · —

1:50 YEAR FLOODLINE — — —

1:25 YEAR FLOODLINE

N

meters 0 100 200

feet 0 200 400 600

Base map drawn at: Provincial Planning Branch
Alberta Department of Municipal Affairs

Prepared by: M. J. Staite
Department of Geography
University of Alberta

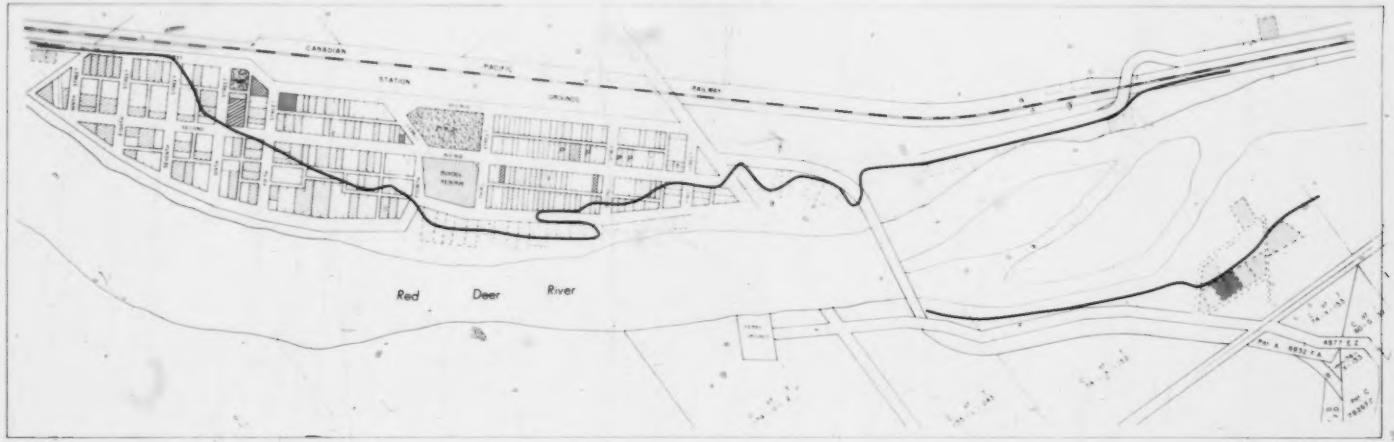
Prepared for: Planning Division
Alberta Department of Environment

Date: January, 1979

APPENDIX H

LEHIGH AND EAST COULEE LAND USE MAPS

EAST COULEE



LEHIGH

LAND USE

(DOES NOT INCLUDE GARAGES, SUMMER KITCHENS OR OTHER OUTBUILDINGS)

- SINGLE FAMILY RESIDENTIAL
- TWO FAMILY RESIDENTIAL
- MULTI-FAMILY RESIDENTIAL
- TRAILER PARK
- CAMPING AND CABINS
- HOTEL/MOTEL
- COMMERCIAL
- INDUSTRIAL/STORAGE
- PARK /OPEN SPACE
- AGRICULTURAL :HAY/GRAZING
  :CULTIVATED
- PUBLIC
- SCHOOL
- CHURCH
- SQUATTER
- VACANT

— ESTIMATED 1:100 YEAR FLOODLINE

meters 0 100 200
feet 0 200 400 600

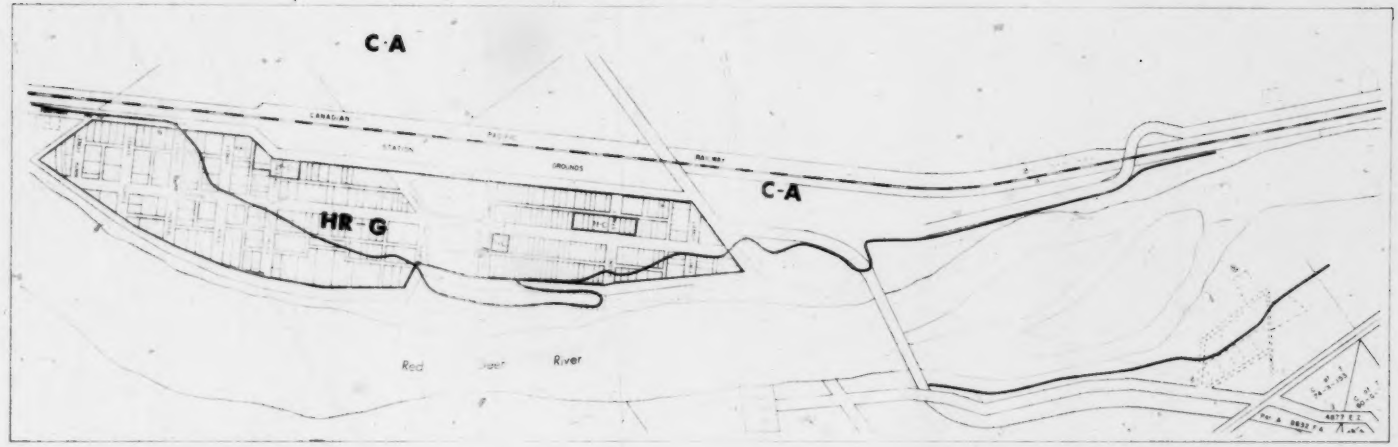
Base map drawn at Provincial Planning Branch
Alberta Department of Municipal Affairs

Prepared by: M. J. Shute
Department of Geography
University of Alberta

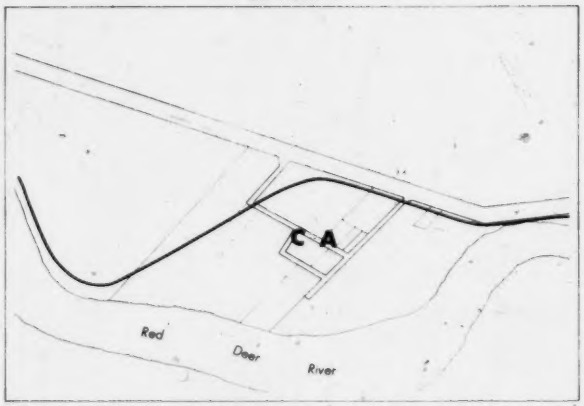
Prepared for: Planning Division
Alberta Department of Environment

Date: January, 1979

EAST COULEE



LEHIGH



LAND USE ZONING

R-1	SINGLE FAMILY RESIDENTIAL DISTRICT
R-2	TWO FAMILY RESIDENTIAL DISTRICT
R-G	GENERAL RESIDENTIAL DISTRICT
MH-P	MOBILE HOME PARK
MH-R	MOBILE HOME RESIDENTIAL DISTRICT
C-B	CENTRAL BUSINESS DISTRICT
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(SOURCE: Improvement District No. 7, 1978, Development Control Bylaw Directions in Force and the City of Drumheller, 1976, Development Control Bylaw, as ammended to Sept., 1978)

——— ESTIMATED 1:100 YEAR FLOODLINE

meters 0 100 200
feet 0 200 400 600

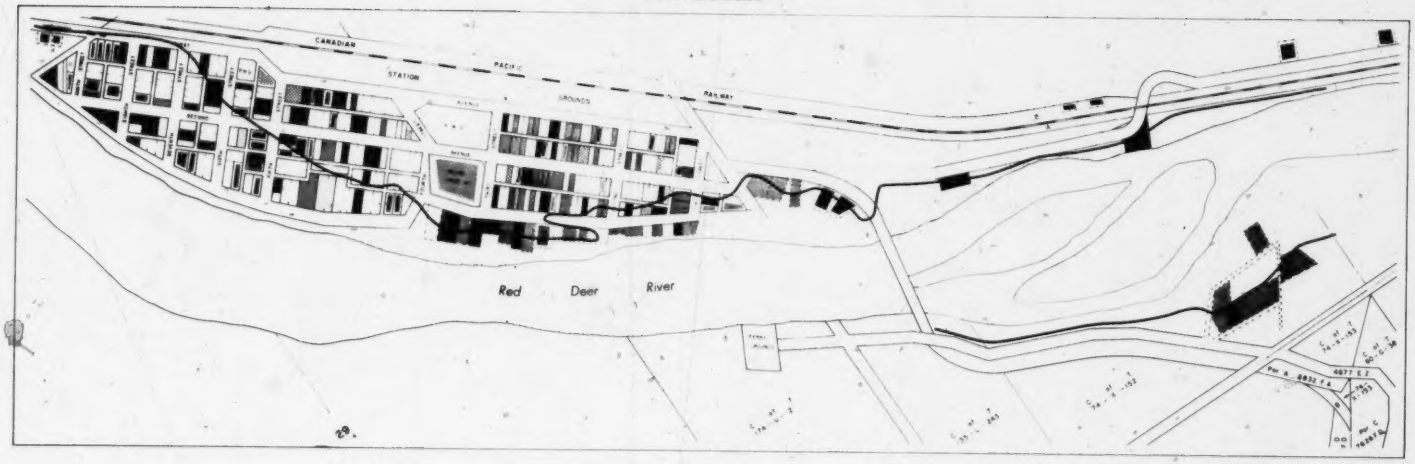
Base map drawn at: Provincial Planning Branch
Alberta Department of Municipal Affairs

Prepared by: M. J. Stuifbergen
Department of Geography
University of Alberta

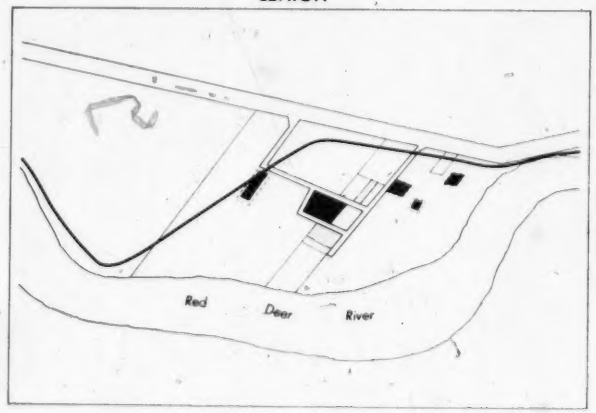
Prepared for: Planning Division
Alberta Department of Environment

Date: January, 1979

EAST COULEE



LEHIGH



BUILDING CLASSIFICATION

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		B (GOOD)
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ESTIMATED 1:100 YEAR FLOODLINE

meters 0 100 200
feet 0 200 400 600

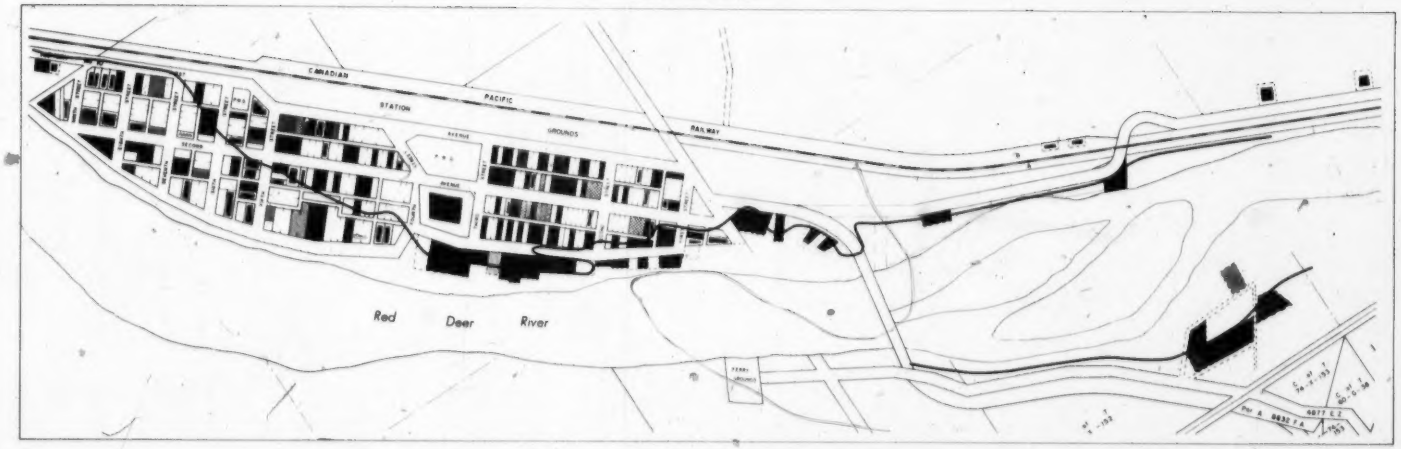
Base map drawn at Provincial Planning Branch
Alberta Department of Municipal Affairs

Prepared by: M. J. Stolte
Department of Geography
University of Alberta

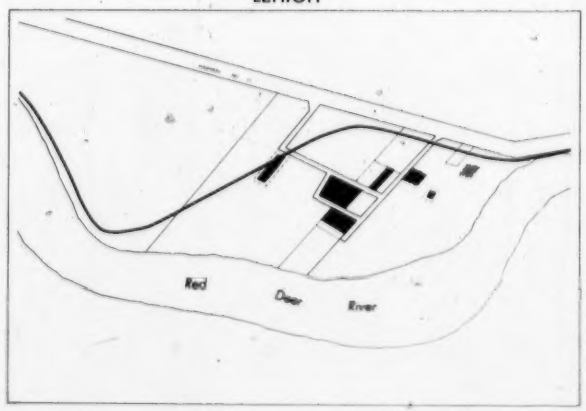
Prepared for: Planning Division
Alberta Department of Environment

Date: January, 1979

EAST COULEE



LEHIGH



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(HEIGHT ABOVE GROUND LEVEL)

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- 0.6-1.0 meter
- 1.0 meter <

POTENTIAL BASEMENT WATER ENTRY POINT / FIRST FLOOR

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- 0-0.5 meter / 0.6-1.0 meter
- 0-0.5 meter / 1.0 meter <

UNOCCUPIED EG. —

— ESTIMATED 1:100 YEAR FLOODLINE

meters 0 100 200
feet 0 200 400 600

Base map drawn at Provincial Planning Branch
Alberta Department of Municipal Affairs

Prepared by: M. J. Slupik
Department of Geography
University of Alberta

Prepared for: Planning Division
Alberta Department of Environment

Date: January, 1979